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(54) **Optical disk, optical disk apparatus, and method for writing figures**

(57) Visible figures (710,720) are written by gather of element regions in which the average reflectivity per area 0.01mm x 0.01mm changes more than 5% from the background region at any of visible wavelengths. Apparatus and methods for writing the visible figures are also disclosed.

FIG. 7(a)

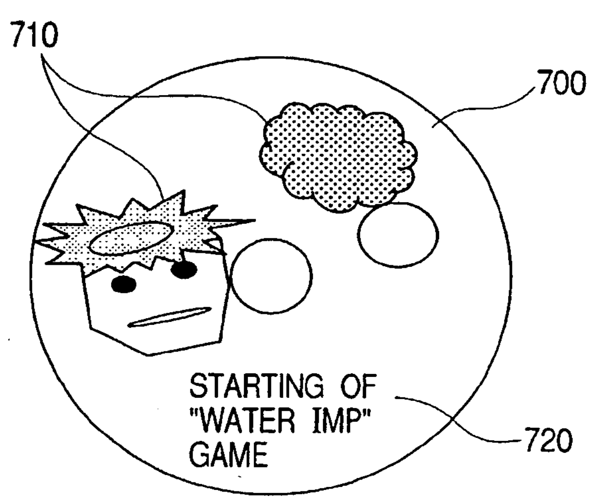

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FIG. 7(b)

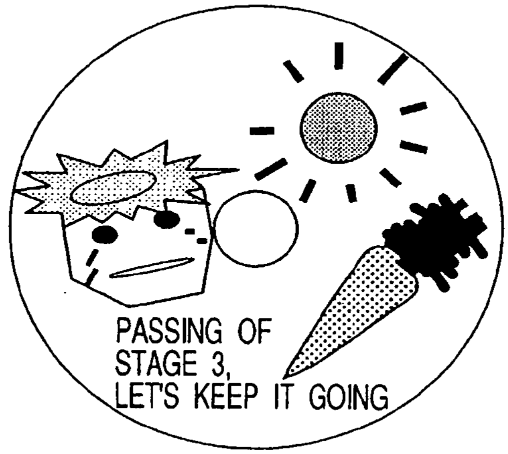
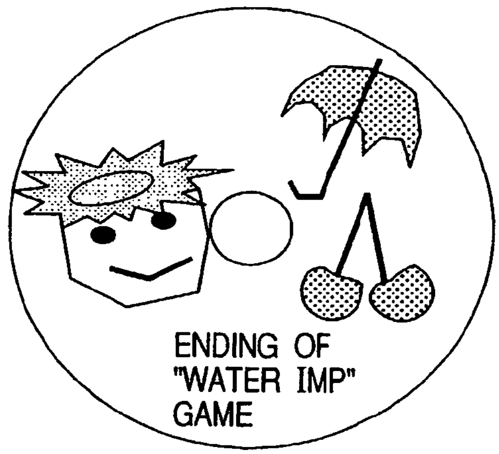

PASSING OF
STAGE 3,
LET'S KEEP IT GOING

FIG. 7(c)


ENDING OF
"WATER IMP"
GAME

Description

Background of the invention

Field of the invention

[0001] The present invention relates to a method for writing on an optical disk figures such as letters and pictures visible with naked eyes, and also to an optical disk apparatus having a function to visibly write on an optical disk figures such as letters and pictures.

Description of Related Art

[0002] There are several principles of recording information on a thin film (recording film) by irradiation with a laser beam. Among them, the one which utilizes the change of atomic arrangement by irradiation with a laser beam, such as the phase change (also called phase transition) and photo-darkening of the film material, which is accompanied by very little deformation of thin film, has the advantage that an optical disk of double-side disk structure or a multi-layer optical disk having a plurality of information planes is obtained by directly bonding together two sheets of disk members. Such optical disks as conventional CD-R, CD-RW, PD, DVD-R, DVD-RW, and DVD-RAM reproduce recorded information by using an apparatus with built-in laser.

[0003] The conventional optical disk needs a reproducing apparatus with a built-in laser source for reproduction of information recorded on an optical disk. Also, the content which the user has recorded on an optical disk could not be confirmed unless the optical disk is reproduced by the reproducing apparatus.

SUMMARY OF THE INVENTION

[0004] The present invention is intended to provide an optical disk that makes visible letters and marks without requiring a reproducing apparatus. Also, the present invention is intended to provide a method of recording visible letters, pictures, and marks on an optical disk without requiring a reproducing apparatus.

[0005] An optical disk is a discoid recording medium in which information which can be reproduced by using difference in reflectivity has been recorded or can be recorded. An optical disk comes in various types, such as the one which has one layer of recording film, the one which has two or more multiple layers of recording film, the one which has a ROM region and a RAM region, the one which is capable of recording and reproducing many times, and the one which is capable of recording once and permits reproduction many times.

[0006] For the recording film of an optical disk, phase-changing materials such as Ge-Sb-Te, In-Sb-Te, Ag-In-Sb-Te, germanide, antimonide, telluride, indide, etc. are usually used. An optical disk that uses a phase-changing material for the recording film records information by utilizing the fact that the phase-changing material of the recording film is made crystalline or amorphous by irradiation with a laser bean which has been modulated by recording information and performs reproduction of information by utilizing the difference in reflectivity between the crystalline region and amorphous region. It is also possible to use for the recording film an organic pigment capable of discoloration by light irradiation/heating in addition to the phase-changing material. The optical disk that uses an organic pigment for the recording film performs recording and reproducing by utilizing the fact that hue changes because the discolored region and the colored region differ in reflectivity at visible wavelengths. The optical disk that uses an organic pigment is the same as the optical disk that uses the phase-changing material in writing method and reproducing method except that rewriting is impossible, if amorphous is replaced by discoloration and crystalline is replaced by coloration in the phase-changing material. The present invention can be applied to optical disks of any type so long as they are optical disks having a recording film or recording region capable of recording by a laser beam.

[0007] Fig. 1 is a diagram showing the difference in reflectivity in the case where a typical optical disk recording film material is made crystalline and amorphous, with the abscissa representing wavelength and the ordinate representing reflectivity. Ramo is reflectivity when the recording film material is made amorphous and Rcry is reflectivity when it is made crystalline. Recording of information in an ordinary optical disk is accomplished by forming amorphous recording marks by laser beam irradiation along the track of the crystalline recording film. And, reproduction of recording information is accomplished by reading off the position of recorded marks or the position of mark edges by utilizing difference in reflectivity between the crystalline region and the amorphous region. The track width of the optical disk is about 0.1-0.8 μm and the mark length is about 0.1-8 μm, and since recording marks are extremely small, it is impossible to recognize individual recording marks with naked eyes.

[0008] The present inventors turned their attention to the fact that the reflectivity of the crystalline region and amorphous region of the optical disk recording film material greatly varies in visible region, and conceived that if large letters and pictures crossing a plurality of tracks are depicted as figures in the recording film by connecting amorphous regions, it will be possible to recognize them with naked eyes by difference in reflectivity between the amorphous region constituting the letters and pictures and the surrounding crystalline region, and developed a method for writing such figures and a figure writing apparatus to realize it. Incidentally, the figure writing apparatus can be realized by incorporating a program for figure writing in an ordinary optical disk recording apparatus.

[0009] In this specification, "recording" means forming recoding marks having "1" and "0" information by

changing the atomic arrangement in the recording film of the optical disk by irradiation with light. "Writing" means writing visible letters and pictures in the optical disk by changing the atomic arrangement in the recording film of the optical disk by light irradiation or heating. "Erasing" means erasing information recorded in the optical disk or making invisible letters and pictures written in the optical disk.

[0010] By the present invention, the following optical disk, optical disk apparatus, or method for writing figures in the optical disk are provided.

(1) An optical disk having a first region and a second region divided in the radial direction characterized in that data is recorded in said first region by recording marks and a visible figure is written in said second region by gather of element regions in which the average reflectivity per area of 0.01 mm × 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

The figure includes pictures, letters, symbols, etc. The background region denotes a region other than element regions of the second region, that is, the region which becomes the background of the visible figure formed by gather of element regions.

(2) An optical disk having a plurality of recording films characterized in that data is recorded in said first recording film by recording marks and a visible figure is written in said second recording film different from said first recording film by gather of element regions in which the average reflectivity per area of 0.01 mm × 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

The figure includes pictures, letters, symbols, etc. The background region denotes a region other than element regions of the second region, that is, the region which becomes the background of the visible figure formed by gather of element regions.

(3) An optical disk having a region in which data for figure writing by recording marks has been recorded and a region in which a visible figure has been formed by gather of element regions in which the average reflectivity per area of 0.01 mm × 0.01 mm differs more than 5% from the background region at any of visible wavelengths which is written based on said data for figure writing in said second recording film.

The figure includes pictures, letters, symbols, etc. The background region denotes a region other than element regions of the second region, that is, the region which becomes the background of the visible figure formed by gather of element regions. The region in which data for figure writing by recording marks is stored and the region in which a visible figure is formed may be on the same recording film or different recording film.

(4) An optical disk having a first region and a second region divided in the radial direction which is constructed such that data can be recorded in said first region by recording marks and a visible figure can be written in said second region by gather of element regions in which the average reflectivity per area of 0.01 mm × 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

(5) An optical disk having a plurality of recording films which is constructed such that data can be recorded in said first recording film by recording marks and a visible figure can be written in said second recording film different from said first recording film by gather of element regions in which the average reflectivity per area of 0.01 mm × 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

(6) An optical disk having a region in which data for figure writing by recording marks is recorded and a region in which a visible figure is formed by gather of element regions in which the average reflectivity per area of 0.01 mm × 0.01 mm differs more than 5% from the background region at any of visible wavelengths which is written based on said data for figure writing in said second recording film.

(7) An optical disk having a ROM region in which an application program and data of a figure to be visibly written in the disk by said application program are recorded, and a RAM region in which a visible figure is written based on the data of a figure recorded in said ROM region.

(8) A figure writing method which comprises writing a visible figure in an optical disk by irradiation with light by causing element regions to gather in which the average reflectivity per area of 0.01 mm × 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

(9) A method of writing a visible figure in an optical disk which comprises a step of reading figure data for figure writing from an optical disk, a step of developing the figure data which has been read into coordinates for writing, a step of converting the coordinates for writing into coordinates on the disk, a step of generating a laser driving pattern for each track based on the figure developed on the coordinates on the disk, and a step of driving the laser based on said laser driving pattern, thereby irradiating the optical disk with beam pulses.

(10) A method of writing a visible figure in an optical disk which comprises a step of developing a figure into coordinates for writing based on the figure data which has been entered, a step of converting the coordinates for writing into coordinates on the disk, a step of generating a laser driving pattern for each track based on the figure developed on the coordinates on the disk, and a step of driving the laser based on said laser driving pattern, thereby irradiating the optical disk with beam pulses.

(11) A method of writing a figure as defined in (10) above, wherein the figure is a letter and/or a symbol.
(12) A method which comprises a step of loading an application program stored in an optical disk, a step of reading data for figure writing while said application program is proceeding, a step of developing the figure data which has been read into coordinates for writing, a step of converting the coordinates for writing into coordinates on the disk, a step of generating a laser driving pattern for each track based on the figure developed on the coordinates on the disk, and a step of driving the laser based on said laser driving pattern, thereby irradiating the optical disk with beam pulses to visibly write said figure on said optical disk.
(13) A method as defined in (12) above, wherein the step of visibly writing said figure is accomplished by gather of element regions in which the average reflectivity per area of 0.01 mm × 0.01 mm differs more than 5% from the background region at any of visible wavelengths.
(14) An optical apparatus which comprises an optical disk driving unit to turn and drive an optical disk, an optical head which has a light source and a light detector and is movable relative to the optical disk, a means to manage separately a region for data recording by recording mark and a region for writing visible figure in the physical user region of the optical disk, an input means to enter data for figure writing, a means to generate waveform for said light source driving from the data for figure writing which has been entered from said input means, and a function to write a visible figure in a region corresponding to the region for writing said visible figure by gather of element regions in which the average reflectivity per area of 0.01 mm × 0.01 mm differs more than 5% from the background region at any of visible wavelengths.
(15) An optical disk apparatus as defined in (14) above, wherein the figure is a letter and/or a symbol.

[0011] Other and further objects, features and advantages of the invention will appear more fully from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] A preferred form of the present invention illustrated in the accompanying drawing in which:

Fig. 1 is a diagram showing the reflectivity characteristics of the optical disk;
Fig. 2 is a schematic block diagram showing one example of the optical disk having the figure writing function according to the present invention;
Fig. 3 is a function detail diagram to explain one example of the system controller;
Fig. 4 is a conceptual diagram showing one example of the sector arrangement of the optical disk;
Fig. 5 is a diagram showing an example in which the recording film of one layer is divided into the data recording area and the figure writing area;
Fig. 6 is a diagram showing an example in which the data recording area and the figure write area are allocated to the optical disk having the multiplayer recording film;
Fig. 7 is a descriptive diagram showing an example in which pictures and letters as visible figures are written in the recording film of one layer of the multiplayer disk according to the present invention;
Fig. 8 is a descriptive diagram of the ratio of the crystalline region (space portion) and the amorphous region (mark portion);
Fig. 9 is a diagram showing an example in which visible letters are written in the optical disk shown in Fig. 5 by the present invention;
Fig. 10 is a descriptive diagram concerning the positioning, synchronizing, and access method at the time of figure writing;
Fig. 11 is a diagram showing one example of the relation of the arrangement of sectors and the coordinates for figure writing;
Fig. 12 is a flow chart showing the processing example of the case where visible figures are written in the optical disk;
Fig. 13 is a descriptive diagram showing the details of processing in the encoder;
Fig. 14 is an enlarged diagram of the coordinates for figure writing and the letter "N" developed on it.
Fig. 15 is a descriptive diagram regarding the formation of writing waveform;
Fig. 16 is a descriptive diagram regarding the color tone;
Fig. 17 is a diagram showing the other example of the method of changing the color tone level;
Fig. 18 is a flow chart showing the process example of writing figures in the figure writing area of the optical disk;
Fig. 19 is a schematic diagram of the optical disk having the ROM region and the RAM region;
Fig. 20 is a process diagram illustrating the production method of the optical disk shown in Fig. 19; and
Fig. 21 is a flow chart concerning the figure writing process to the disk plane performed as the game proceeds.

DETAILED DESCRIPTION OF THE PREFERRED EMBODYMENTS

[0013] In what follows, the mode of carrying out the invention will be explained with reference to the drawings.

[0014] Fig. 2 is a schematic block diagram showing one example of the optical disk apparatus having a function of writing figures according to the present invention. Incidentally, for the convenience of explanation, how the

optical disk 201 is mounted on the apparatus is shown. Although the optical disk 201 is essential to write information, the optical disk 201 is dismounted from and mounted on the optical disk apparatus according to need. The optical disk apparatus is constructed of a semiconductor laser 211, an optical head 210 which is capable of moving in the radial direction of the optical disk 201 and is provided with a photodetector 212 and an object lens 213, a motor 220 which turns and drives the optical disk 201, a laser driver 230 which drives the semiconductor laser 211 according to the pattern generated by a pattern generating circuit 240, a system controller 250 which controls the entire apparatus, an operating system 260, an application soft 270, and an input means 280 which enters data recording information and figure writing information. Incidentally, although not shown, the optical head 210 is provided with an actuator to control the position in the optical axis direction of the object lens 210 and the position in the direction vertical to the optical axis for autofocusing and tracking, and is provided with a servocontroller which generates actuator driving signals based on signals detected by the optical head 210.

[0015] When the optical disk is mounted on the optical disk apparatus having a figure writing function and instructions of figure writing and information of figures to be written are delivered from the upper level controllers such as the application soft 270 and operating system 260 through the input means 280, the system controller 250 positions the focal point of the laser beam generated from the optical head 210 at an adequate position of an adequate information layer on the optical disk 201 and drives the laser driver 230 and writes figures according to the writing pattern.

[0016] Fig. 3 is a function detailed diagram explaining one example of the system controller. Input signals from the input means 280 are delivered to the file system 311 of the system controller 250 through the application soft 270 and operating system 260 and accumulated in the buffer 320 through the device driver 312. The function of the application soft 270, operating system 260, file system 311, and device driver 312 which are surrounded by broken lines in Fig. 3 is realized by the software 310. This software 310 differs from the software of an ordinary optical disk apparatus which only performs data recording and reproduction in that "a function to control the data recording area and the figure writing area" is added. "The function to control the data recording area and the figure writing area" is assigned to the file system 311 or the device driver 312.

[0017] Fig. 4 is a conceptual diagram showing one example of the sector arrangement of the optical disk. In the case where a figure is written together with a record of data in a sheet of optical disk, the logical user region in which the user can record data or write a figure is divided into the logical user region 401 for data recording and the logical user region 402 for figure writing so as to control. In the example of Fig. 4, the sector number of the logical user region 401 for data recording is allocated to the smaller ones (from 0 to k-1) and the logical user region 402 for figure writing is allocated to the larger ones (from k to z), thereby establishing separately in the optical disk. If the data recording area is allocated to that of larger sector number, errors are liable to occur during reproduction in the data recording area; therefore, it is established in this way. The ratio of k and z is determined by the application, and in the case of a disk for figure writing only which has no data recording area, k = 0. In the case where half an area of the region capable of recording of the optical disk is used as a figure writing, k is an integer value of approximately a half of z. Incidentally, in consideration of compatibility with the existing system in which the handling of recording data is 16 sectors each, making k a multiple of 16 is desirable because the waste of capacity is reduced.

[0018] In the case where the division of the data recording area and the figure writing area is accomplished by the file system 311 of the system controller 250, the arrangement information of the logical user region 401 for data recording and the logical user region 402 for figure writing is recorded in the logical user region for recording in the user region in the optical disk and referenced at the time of recording reproducing. In the case where the division of the data recording area and the figure writing area is accomplished by the device driver 312, the arrangement information of the logical user region 401 for data recording and the logical user region 402 for figure writing is controlled for each application by the device driver 312 and referenced at the time of recording reproducing.

[0019] In the case where a single layer of recording film is divided into the data recording area and the figure writing area, it is desirable that the data recording area is allocated to that closer to the lead-in area than the figure writing area and the figure writing area is allocated to that far from the lead-in area. As shown in Fig. 5, in the optical disk 500 like DVD-RAM, DVD-RW, DVD-R, CD-R, and CD-RW which has the lead-in area inside, the data recording area 510 for recording digital data is formed inside and the figure writing area 520 in which letters and figures (such as pictures) visible with naked eyes are written is formed outside. The ratio of the size of the data recording area 510 and the figure writing area 520 can be determined for each object; however, in order to recognize with naked eyes the letters and pictures written in the figure writing area 520, it is necessary that the width in the disk radial direction of the figure writing area 520 should be 0.01 mm or more.

[0020] In the case of an optical disk, such as double-layer disk, which has recording film in multiple layers, it is permissible to allocate the data recording area and the figure writing area to different recording films. Fig. 6 is a sectional schematic diagram showing one example of a double-layer disk having two layers of recording film. The optical disk 600 of this example has a structure that a first recording film 620 and a second recording

film 640 are laminated on a substrate 610 holding a spacer layer 630 between them and a protective coat 650 is formed to the upper most layer. In the case of such an optical disk 600 having multiple recording films, if the figure writing area is formed at the light incident side, the reflectivity change is large and the recording power variation becomes large; therefore, it is desirable to allocate the recording film 620 near the light incident side to the data recording area to record digital data and to allocate the recording film 640 far from the light incident side to the figure writing area to write letters and pictures visible with naked eyes.

[0021] Fig. 7 is a descriptive diagram showing one example of in which pictures and letters as visible figures are written in one layer of recording film of multiplayer disk according to the present invention. The optical disk 700 of this example has a recording film of phase-change type recordable by the user, and visible figures 710 and letters 720 are written in the recording film. In writing pictures and letters, like the case of recording ordinary digital data, the optical disk is irradiated with a laser beam according to figure data of pictures and letters to bring about phase change in a prescribed region of the recording film. If a material capable of irreversible phase change is used for the recording medium, the above-mentioned figures such as pictures and letters can be rewritten, and visible figures can be rewritten as from Fig. 7(a) to Fig. 7(b), Fig. 7(c), according to the change of situation.

[0022] Here, in the case of ordinary data recording, in the user region as shown in Fig. 8(a) a modulating method such that the ratio of the crystalline region (space portion) 801 and the amorphous region (mark portion) 802 is distributed approximately evenly (5:5) in the circumferential direction in the recording region of the recording film is adopted, but in writing visible pictures and letters the mark by amorphous region is formed in a macro gather across a plurality of tracks in the crystalline region on the recording film; therefore, the ratio of the crystalline region (non-writing portion) and the amorphous region (writing portion) is not limited to approximately even. To make it more readily visible, in the macro gather in the writing region, as shown in Fig. 8(b), if the ratio of crystalline region (non-writing portion)/amorphous region (writing portion) in the circumferential direction in the recording region of the recording film is made 6/4 or above, the contrast becomes large and therefore this is desirable. Like this, the amorphous region and the crystalline region of the recording film differ in reflectivity distribution in visible wavelengths and marks by the amorphous region gather to form a large region and therefore hue/lightness/ saturation varies and it becomes possible to recognize with naked eyes written pictures and letters.

[0023] Fig. 9 is a diagram showing an example in which visible letters have been written according to the present invention in the optical disk shown in Fig. 5. This disk 900 performs recording and reproduction of ordinary digital data by using the data recording area set in the zone inside the inner circumference and writes the visible letter 921 in the figure writing area 920 set in the zone outside the outer circumference. The visible letters are rewritable, and it is possible to write additional letters 922 like from Fig. 9(a) to Fig. 9(b) according to change in situation. Writing of pictures and signs as well as letters is also possible in the same way.

[0024] The synchronizing method in the circumferential direction of the disk regarding positioning, synchronizing, and access method at the time of figure writing is as per written below. In the disk, information which shows the kind of disk is recorded, and the sector arrangement on the disk is judged based on this. Positioning, synchronizing, and access at the time of figure writing are accomplished according to tracking signals, ID reproducing signals of pit, and wobble signals due to irregularities and deformation attaching to the substrate of the optical disk. If synchronizing and/or position detecting is performed by address information such as tracking signals, ID reproducing signals of pit, and wobble signals due to irregularities and deformation set on the substrate of the optical disk, the accuracy of the writing position rise, and more distinct letters and/or pictures, signs are written and it is preferable. In addition, as shown Fig. 10, it is permissible to perform positioning, synchronizing, and access from the moving distance from the reference point of the innermost circumference. The reference point may be other position instead of the innermost circumference. In this case, in the case of a certain amount of movement, by issuing synchronizing signals in the radial direction, the amount of movement from the radial position can use the driving signals/moving time signals etc. for a certain period of time as the synchronizing signals in the radial direction.

[0025] The optical disk of the present invention having the figure writing function has a corresponding table for arrangement information of sectors and coordinates for figure writing for each kind of disk such as CD-R, CD-RW, PD, DVD-R, DVD-RW, and DVD-RAM. Fig. 11 is a diagram showing one example of the relation of the sector arrangement and the coordinates for figure writing. According to this example, sector 1101 corresponds to the coordinate (R105, T201) ~ (R105, T201) and the sector 1102 corresponds to the coordinates (R105, T211) ~ (R105, T220). The figure based on the data for figure writing is caused to correspond to the sector on the optical disk upon development into the coordinates for figure writing, and the pattern for laser driving is generated based on it.

[0026] Next, we explain regarding the processing example of the case of writing letters, figures, or pictures on the recording surface of the optical disk. Here, we explain regarding the example in which data such as image data and letters input from the keyboard as an index for it are written in the visible form. The index data are data which may be input by the user or data attached to the recording data such as pictures or data determined

by the system. Taking image data such as photographs as an example, it is possible to write the title and date and time of image as the index. For example, as Fig. 9 (a) shows, the title together with the image data is written as visible letters, and subsequently other image data are recorded and it is possible to additionally write the title as shown in Fig. 9(b). In addition, the using method such as writing the owner or the user ID or the capacity of the optical disk as the index is also possible.

[0027] Fig. 12 is a flow chart showing a process example in the case where visible figures are written in the optical disk. As the disk is thrown in/the apparatus power source is thrown in, the discrimination process of whether the figure writable disk or not is performed (step 1201) first. In the case where a ROM disk or a disk of other standard than the apparatus is thrown in, the error process is performed as being not writable (step 1202). If the disk is figure writable, then the discrimination process of disk kind is performed next (step 1203). In the discrimination step of disk kind, correspondence between the coordinates for figure writing and the sector arrangement of the optical disk is performed as explained with reference to Fig. 11. Then, figure writing data is entered (step 1204). As data is entered, the writing of figure data is performed though the writing preparation (step 1205). After the figure writing process has been completed, process is repeated by returning from step 1207 to step 1204 if there are additional data, and the process terminates if there are no input data.

[0028] The figure writing preparation and figure writing process are performed under the control of the system controller 250. The figure writing preparation is a process of moving the optical head to the figure writing position on the optical disk, encoding the writing content and the writing color tone, and transmitting to the writing means. As shown in Fig. 3, when an input signal containing the address information showing the writing content and the place to start writing to the optical disk is sent to the system control 250, the information is stored in the buffer 320, and is sent to the controller 340. In the controller 340, the synchronizing signal output from the synchronizing circuit 330 and the input signal from the buffer 320 are set to the encoder 350 in timing.

[0029] Fig. 13 is a descriptive diagram showing the detail of processing in the encoder 350. The figure writing data (character "N" in the example shown) entered from the keyboard is, after addition of font size information, developed into the coordinates for figure writing, and conversion into the actual figure writing coordinates set on the disk is performed. For example, "N" is developed into X-coordinate axis 1~20, Y-coordinate 1~20. Writing is performed in the area corresponding to (X5, Y5), (X5, Y6), (X5, Y7) of these. Based on this writing information and the corresponding table of the sector and the figure writing coordinate as shown in Fig. 11, the figure writing pattern is formed. In the case of the shown example, (X5, Y5), (X5, Y6), (X5, Y7) are converted into (R105, T105), (R105, T106), (R105, T107), respectively, so as to correspond the write starting point (R101, T101) of the figure writing coordinate on the disk with (X1, Y1) of the coordinates for figure writing.

[0030] Fig. 14 is an enlarged diagram of the coordinates for figure writing and the letter "N" which has been developed thereon. The region (X17, Y5) which becomes (R117, T105) after conversion is formed from a plurality of amorphous regions, as shown enlarged under Fig. 14. In this, for simplification, it is formed with 8 tracks, but to be actually visible, the area shown with one coordinate point of the coordinates for figure writing needs an area larger than 0.01 mm × 0.01 mm, for example, in the case of an optical disk having a track width about 0.6 μm wide, it is necessary to correspond to about 17 tracks or more and a length more than 0.01 mm. The shape of the region of 0.01 mm × 0.01 mm more may be a square, rectangle, trapezoid, hexagon, triangle, or a shape close to them. Also, for the written figure to be visible, it is necessary to cause the reflectivity change more than 5% compared with the surrounding at any of visible wavelengths to occur in the region of width more than about 0.01 mm × 0.01 mm. The reflectivity change is referred to as the average reflectivity change in the region. Either in the case where the area in which the reflectivity change occurred is small or in the case where the reflectivity change is small, it was difficult to recognize the written figure.

[0031] Fig. 15 is a descriptive diagram regarding the formation of writing waveform. In the encoder 350 of the system controller 250, based on the corresponding table of the sector and the figure writing coordinates, on the basis of the figure developed in the figure writing coordinates, the fundamental writing pattern taking timing in response to the synchronizing signal for each tack following the recording order is formed. In Fig. 15, a writing pattern corresponding to the figure writing coordinates (R105, T105) on the disk was illustratively shown. In the pattern generating circuit 240, a writing pattern is added to this in response to the color tone and a final writing waveform is generated and stored in the buffer. Regarding the color tone, we will mention later.

[0032] With reference to Fig. 2, by driving the laser driver 230 by the writing waveform output from the pattern generating circuit 240, the semiconductor laser 211 emits light, the laser beam modulated in terms of time in response to information to be written from the optical head 210 is irradiated to the optical disk 201, and a figure consisting of letters and pictures is written on the optical disk 201. The driving current of the semiconductor laser 211 is changed in synchronism with the synchronizing signal in the circumferential direction of the optical head 210 or the writing clock fundamental wave.

[0033] Here, we explain regarding the color tone. Fig. 16(a) is a schematic diagram which showed the power level (writing waveform) and the writing content at the time of modulating the laser light for one track portion in one coordinate point of Fig. 14 and making amorphous the recording film of the optical disk. The black dot por-

tion shown under the recording waveform represents the region in which the recording film of phase-change type has been made amorphous by laser beam irradiation. In the drawing, Tw represents the window width, Pw represents the writing power, and Pe represents the erasing power. In this way, as the recording film is made amorphous by irradiating the recoding film of the optical disk with a high power, a plurality of amorphous regions formed as shown in Fig. 14. When this is viewed, it looks as though one letter "N" is formed.

[0034] Also, when a high power is partially omitted at the modulation time of laser beam, the ratio which the amorphous region occupies decreases and the ratio which the crystalline region occupies increases. Like this, if the area ratio of the amorphous region per one coordinate region is made small and the average reflectivity difference is made smaller, the contrast at the viewing time decreases, and it is possible to change the level of color tone compared with the case of Fig. 16(a). If the average reflectivity difference is changed stepwise like this, it is possible to change the level of color tone stepwise.

[0035] In addition, the method of changing the color tone level may be decreasing the number and length of the amorphous region 1701 as shown in Fig. 17(a) or decreasing part of the power to make amorphous as shown in Fig. 17(b), making it multipulse, narrowing the width of the amorphous region 1702, or making small the power to make amorphous narrowing the amorphous region. It is permissible to adopt the method of changing the writing track number, such as leaving the figure writing track alternately. Here, we explained regarding the example of forming a figure consisting of letters and pictures in the amorphous region, but it may be permissible to form a figure in the crystalline region.

[0036] The data recording performs recording without space sequentially in the address order from the smaller address number except in the case where it becomes a recording unable region due to error. However, the figure writing does not write in the address order but is written on the basis of the writing pattern only in the area which needs writing on the basis of the writing coordinates. In this case, in the no-writing region such as (X1, Y1), (X1, Y2), (X1, Y3), ... in Fig. 14, writing is not performed. Therefore, writing is performed at random addresses.

[0037] In the case where the data to perform figure writing is image data, the input data becomes the pattern information which has developed the image on the coordinates as shown in Fig. 14. In addition to taking out the image data from the external input, it is permissible to read out data previously stored in the optical disk apparatus. Subsequent processing such as conversion of written coordinates onto the disk and writing pattern preparation is the same as the case in which figure writing is performed based on the character data entered from the keyboard.

[0038] As the method of rewriting, in case of writing after overall erasing of the rewriting region before figure writing, although rewriting time is long, there is no dislocation of letters and pictures written previously and letters and pictures to be newly written, it is written beautifully. And, there is no need to record the previously written content in the optical disk of the optical disk apparatus, and the system is inexpensive. In the case where only altered points are rewritten without overall erasure, it is necessary to record the previously written content in the optical disk or the optical disk apparatus, but there is an advantage of reducing the writing time.

[0039] Fig. 18 is a flow chart showing a process example in the case where a figures such as letters and pictures is written in the figure writing area of the same optical disk using the figure writing data recorded in the data recording area of the optical disk. As the disk is thrown in/the apparatus power source is thrown in, the discrimination process of whether the figure writable disk or not is performed (step 1801) first. In the case where a ROM disk or a disk of other standard than the apparatus is thrown in, the error process is performed as being not writable (step 1802). If the disk is figure writable, then the discrimination process of disk kind is performed next (step 1803). In the discrimination step of disk kind, correspondence between the coordinates for figure writing and the sector arrangement of the optical disk is performed as explained with reference to Fig. 11. Then, data for figure writing is read from the data recording area (step 1804). As data is entered, the writing of figure data is performed though the writing preparation (step 1805). After the figure writing process has been completed, process is repeated by returning from step 1807 to step 1804 if there are additional data, and the process terminates if there are no data for figure writing. When the content of visible figure recorded in the figure writing area is contained in the record data of the optical disk as above, it is possible to correspond the written content with the record content of the optical disk.

[0040] It is possible to form the ROM region and RAM region in the optical disk so that data for figure writing is stored in the ROM region and visible figures such as pictures and letters are written in the area for figure writing set in the RAM. Fig. 19 is a schematic diagram of a disk having such a ROM region and RAM region, and Fig. 19(a) is a schematic plan view and Fig. 19(b) is a schematic AA' sectional view thereof. This optical disk 1900 has the ROM region 1910 formed inside in which an application program such as game for example and data for writing visible figures such as pictures and letters used in the phase in the advance of the game is stored and the RAM region formed outside in which data is recorded and visible letters and pictures are written. The ROM region 1910 has the ROM reflecting layer 1912 formed on the ROM substrate 1911 and the RAM region has the RAM recording film 1922 formed on the RAM substrate 1921. The protective coat 1923 is formed on the ROM reflecting layer 1912 and the RAM

recording film 1922.

[0041] Fig. 20 is a process diagram to explain the manufacturing method of the optical disk shown in Fig. 19. First, as shown in Fig. 20(a), on a polycarbonate substrate in which both of a RAM substrate 1921 diameter 12 cm, thickness 0.6 mm having grooves for tracking on the surface and a ROM substrate 1911 having concave-convex information are combined a ROM reflecting layer material 1915 is made film through the outer circumferential and central mask 1914, and a ROM reflecting layer 1912 was made. Then, as shown in Fig. 20(b), through the inner circumferential and central mask 1924, the RAM recording film material 1925, that is, the lower protective layer, the RAM recording film, the upper protective layer, and the reflective layer are sequentially formed, and the RAM recording film 1922 was formed as shown in Fig. 20(c). The protective coat was formed further thereon. As the protective layer material, $ZnS\text{-}SiO_2$, oxide, nitride, etc., and as the reflective layer, Al alloy, Ag alloy, Au alloy, etc. were used. The formation of the laminate layer was performed by a magnetron sputtering apparatus. After that, the protective coat 1923 was formed on the ROM reflective layer 1912 and RAM recording film 1922. After the protective coat layer 1923 was formed, initialization of the RAM recording film 1922 was performed. Here, the ROM reflective layer 1912 was formed before the RAM recording film 1922, but this order may be reversed.

[0042] Then, we explain regarding an example of the case to which the present invention was applied to game. In the optical disk a program of game as an application program is recorded and figure writing data for visible pictures and letters is also recorded. These data can be recorded in the ROM region of the optical disk. Also, the optical disk has the RAM region to write figures such as visible pictures and letters. It is supposed that the game proceeding information showing in which stage the game was finished at the previous game finish time and the information showing figures for which stage was written in the disk plane at the previous game finish time are recorded in the RAM region of the optical disk. As an example, we explain regarding "Kappa Game".

[0043] "Kappa Game" assumed herein is a game to forecast weather from such items as outlook weather, weather chart, air temperature, infrared photographs from satellites, etc. There are a plurality of stages according to the degree of ease and difficulty of weather forecast. If the weather forecast comes true, it is possible to proceed to the next stage. At the game start time and until the stage 1 is cleared, the figure writing of the initial state shown in Fig. 7(a) is performed on the disk plane. Each time the stage is cleared the writing information to the disk plane is altered, when the stage 3 is cleared the visible pictures and letters as shown in Fig. 7(b) are written in the optical disk plane, and after the final stage has been finished the pictures and letters as shown in Fig. 1(c) are to be written.

[0044] Fig. 21 is a flow chart concerning the figure writing process to the disk plane which is executed with the advance of this game. As the optical disk in which the game program is stored is loaded into the optical disk apparatus and the game starts, the optical disk apparatus reads information at the previous game finish recorded in the RAM region in the optical disk, that is, the game advance information showing at what stage the game was completed (step 2101). Also, in the same way, information showing figures for what stage are written in the current disk plane is read out from the RAM region of the optical disk (step 2102). After that, the game proceeds by the user's input action in response to the game program.

[0045] When the stage is cleared, the judgment of the step 2103 becomes Yes, the advance information of the game is transmitted to the system controller, the figure writing data is read from the ROM region in accordance with the "stage clear information" showing what stage has been cleared (step 2104). The system controller converts the figure writing data which has been read into the waveform for writing and the writing position information, performs the figure writing process (step 2105). In the case where the judgment of step 2103 is No, it judges whether or not to finish the game (step 2106), returns to step 2103 in the case of game continuation. Also, in the case where the game is finished, the game proceeding information is recorded in the RAM region of the optical disk (step 2107), after recording the figure of what stage is written in the disk plane (step 2108), it ends. Thus, the pictures and letters visible with naked eyes which appear on the disk plane of the optical disk change as shown in Fig. 7. The users of the game bring their own game disks and can enjoy showing one another how many stages they have cleared.

[0046] Here, we explained regarding the example in which the figure writing data is recorded in the same optical disk as that in which the game program was recorded, but it is not always necessary to store the figure writing data in the optical disk. For example, the figure writing data may be stored in the optical disk apparatus (game machine) or the application soft. In this case, the figure writing data is read from the optical disk apparatus or application soft according to the stage clear information and transmitted to the writing means. Also, it is not always necessary to record in the optical disk the game advance information showing the stage at which the game was finished or the information showing the disk plane in which the figure for the stage is written, the information may be held in the game machine (optical disk apparatus).

[0047] Also, as the figure writing means, the type causing the atomic arrangement change of the recording film material by irradiating the recording film with a laser beam as shown in Fig. 2 is preferable because the precision of the writing position is high. However, causing the atomic arrangement change of the recording film material by irradiating the recording film with light such as xenon lamp and halogen lamp other than laser beam

is acceptable. By this method, the writing position precision is worse compared with the method of laser beam irradiation, it is possible to shorten the writing time. Moreover, causing the atomic arrangement change by heating with other means than heat is also acceptable.

[0048] In the case where the figure writing is performed by laser irradiation, if the spot shape of laser beam is a circle or close to a circle, larger than the minimum value of recording mark length/width, and less than two times of the above-mentioned minimum value, the reproduction of the recorded mark is possible and the figure writing is also possible and therefore preferable. In order to perform the figure writing at a high speed, there is a method to use a light spot of elongated circle or ellipse long in the disk radial direction, but is not suitable for the reproduction of the recorded marks. If it has an optical head having both of the spot shapes which change into a circle or close to a circle at the recording reproducing time of data and an elongated circle or an ellipse at the figure writing time, the recording reproducing of data is possible and the figure writing time becomes short and therefore is preferable. Also, it may have two kinds of optical heads for the recording reproducing of the recorded marks and for the figure writing.

[0049] As explained above, according to the present invention, it is possible to write visible letters and pictures on an optical disk.

[0050] The foregoing invention has been described in terms of preferred embodiments. However, those skilled, in the art will recognize that many variations of such embodiments exist. Such variations are intended to be within the scope of the present invention and the appended claims.

Claims

1. An optical disk (201, 500, 900, 1900) having a first region (510, 910, 1910) and a second region (520, 920, 1920) divided in the radial direction **characterized in that** data is recorded in said first region by recording marks and a visible figure is written in said second region by gather of element regions in which the average reflectivity per area of 0.01 mm x 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

2. An optical disk (600) having a plurality of recording films (620, 640) **characterized in that** data is recorded in said first recording film (620) by recording marks and a visible figure is written in said second recording film (640) different from said first recording film by gather of element regions in which the average reflectivity per area of 0.01 mm x 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

3. An optical disk having a region in which data for figure writing by recording marks has been recorded and a region in which a visible figure has been formed by gather of element regions in which the average reflectivity per area of 0.01 mm x 0.01 mm differs more than 5% from the background region at any of visible wavelengths which is written based on said data for figure writing in said second recording film.

4. An optical disk having a first region and a second region divided in the radial direction which is constructed such that data can be recorded in said first region by recording marks and a visible figure can be written in said second region by gather of element regions in which the average reflectivity per area of 0.01 mm x 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

5. An optical disk having a plurality of recording films which is constructed such that data can be recorded in said first recording film by recording marks and a visible figure can be written in said second recording film different from said first recording film by gather of element regions in which the average reflectivity per area of 0.01 mm x 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

6. An optical disk having a region in which data for figure writing by recording marks is recorded and a region in which a visible figure is formed by gather of element regions in which the average reflectivity per area of 0.01 mm x 0.01 mm differs more than 5% from the background region at any of visible wavelengths which is written based on said data for figure writing in said second recording film.

7. An optical disk having a ROM region in which an application program and data of a figure to be visibly written in the disk by said application program are recorded, and a RAM region in which a visible figure is written based on the data of a figure recorded in said ROM region.

8. A figure writing method which comprises writing a visible figure in an optical disk by irradiation with light by causing element regions to gather in which the average reflectivity per area of 0.01 mm x 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

9. A method of writing a visible figure in an optical disk which comprises a step of reading figure data for figure writing from an optical disk, a step of developing the figure data which has been read into coordinates for writing, a step of converting the coordinates for writing into coordinates on the disk, a

step of generating a laser driving pattern for each track based on the figure developed on the coordinates on the disk, and a step of driving the laser based on said laser driving pattern, thereby irradiating the optical disk with beam pulses.

10. A method of writing a visible figure in an optical disk which comprises a step of developing a figure into coordinates for writing based on the figure data which has been entered, a step of converting the coordinates for writing into coordinates on the disk, a step of generating a laser driving pattern for each track based on the figure developed on the coordinates on the disk, and a step of driving the laser based on said laser driving pattern, thereby irradiating the optical disk with beam pulses.

11. A method of writing a figure as defined in Claim 10, wherein the figure is a letter and/or a symbol.

12. A method which comprises a step of loading an application program stored in an optical disk, a step of reading data for figure writing while said application program is proceeding, a step of developing the figure data which has been read into coordinates for writing, a step of converting the coordinates for writing into coordinates on the disk, a step of generating a laser driving pattern for each track based on the figure developed on the coordinates on the disk, and a step of driving the laser based on said laser driving pattern, thereby irradiating the optical disk with beam pulses to visibly write said figure on said optical disk.

13. A method as defined in Claim 12, wherein the step of visibly writing said figure is accomplished by gather of element regions in which the average reflectivity per area of 0.01 mm x 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

14. An optical apparatus which comprises an optical disk driving unit (220, 250) to turn and drive an optical disk (201), an optical head (210) which has a light source (211) and a light detector (212) and is movable relative to the optical disk, a means to manage separately a region for data recording by recording mark and a region for writing visible figure in the physical user region of the optical disk, an input means (280) to enter data for figure writing, a means to generate waveform for said light source driving from the data for figure writing which has been entered from said input means, and a function to write a visible figure in a region corresponding to the region for writing said visible figure by gather of element regions in which the average reflectivity per area of 0.01 mm x 0.01 mm differs more than 5% from the background region at any of visible wavelengths.

15. An optical disk apparatus as defined in Claim 14, wherein the figure is a letter and/or a symbol.

FIG. 1

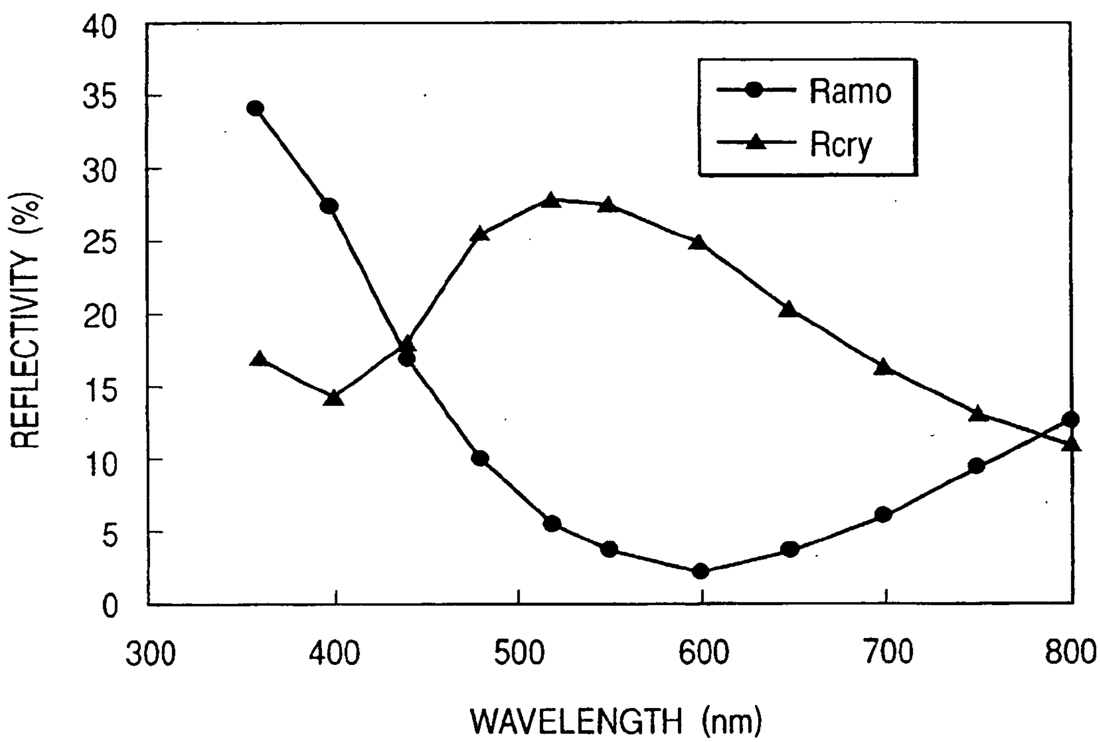

40
35
30
25
20
15
10
5
0
REFLECTIVITY (%)
Ramo
Rcry
300
400
500
600
700
800
WAVELENGTH (nm)

FIG. 2

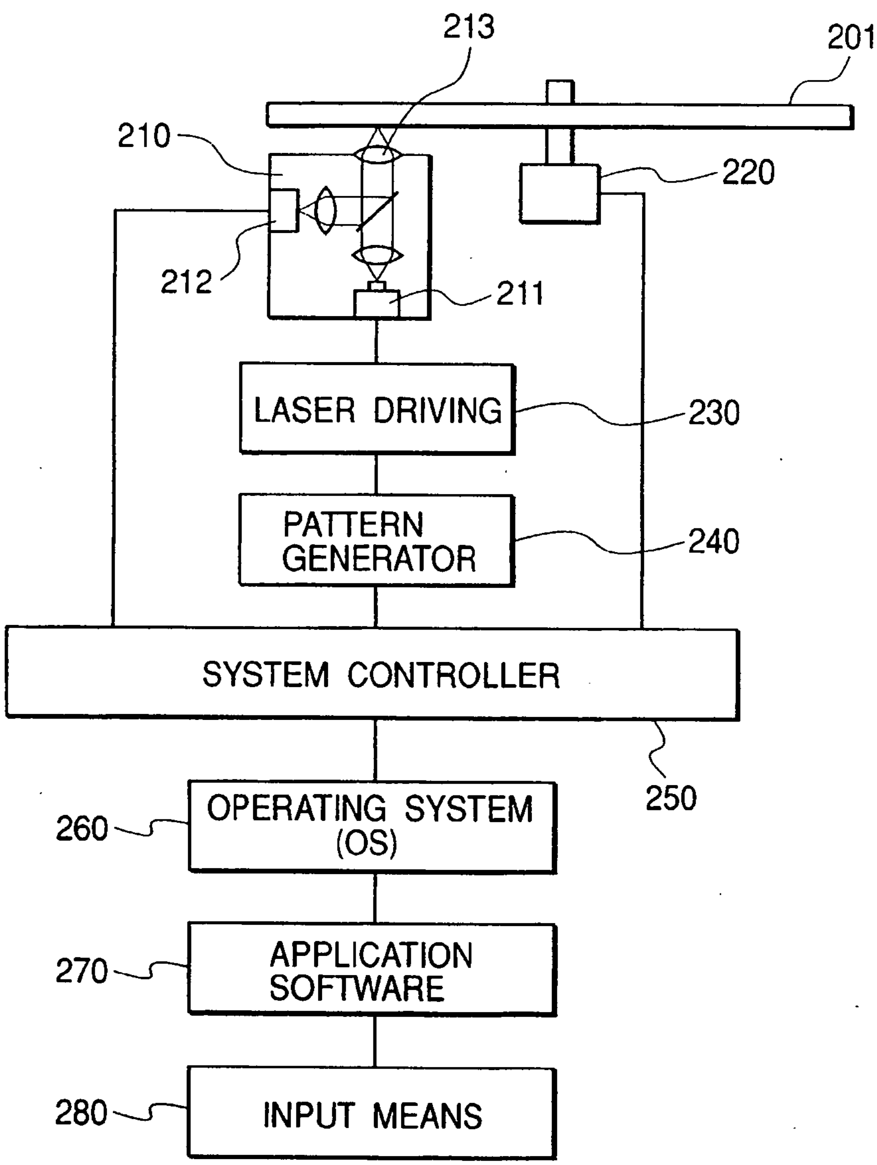

213
201
210
220
212
211
LASER DRIVING
230
PATTERN GENERATOR
240
SYSTEM CONTROLLER
250
260
OPERATING SYSTEM (OS)
270
APPLICATION SOFTWARE
280
INPUT MEANS

FIG. 3

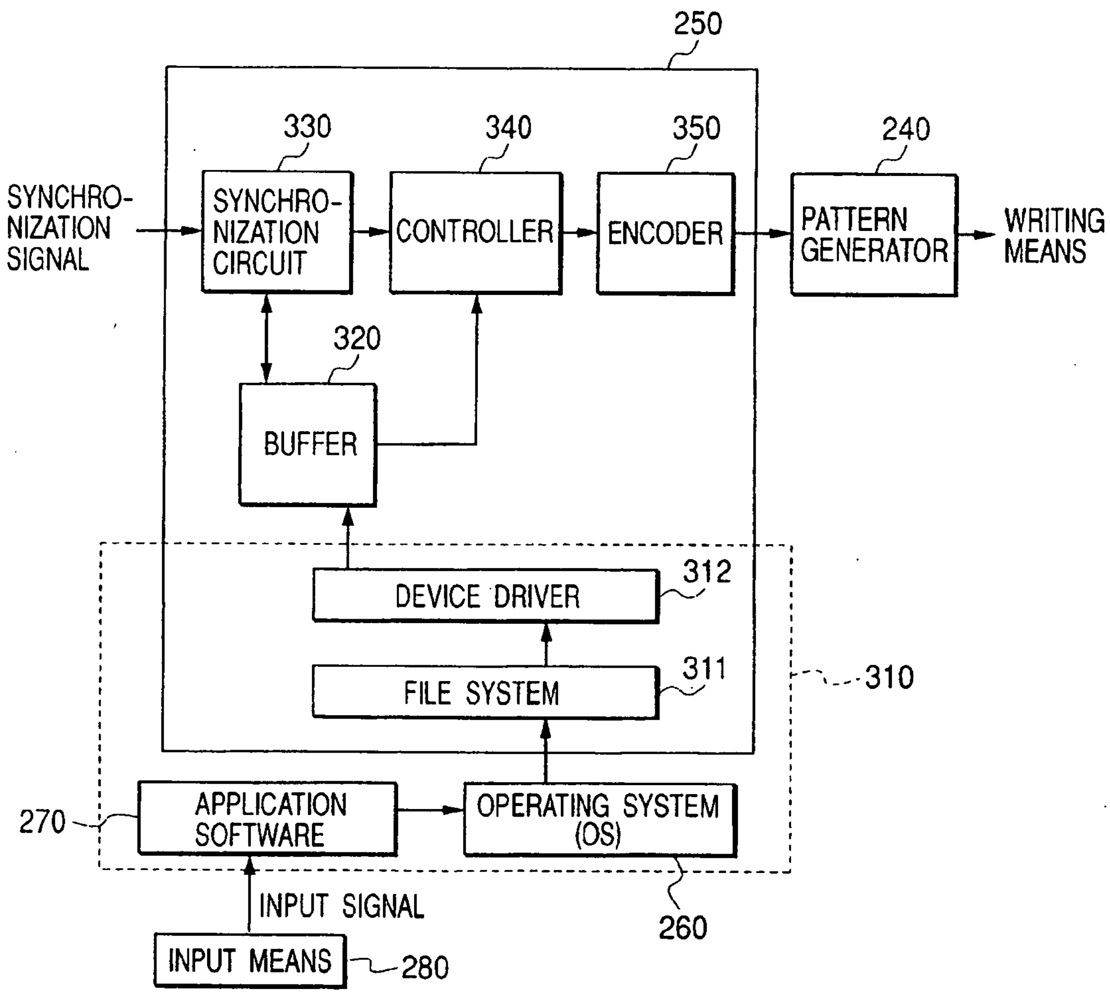

250
330
340
350
240
SYNCHRO-
NIZATION
SIGNAL
SYNCHRO-
NIZATION
CIRCUIT
CONTROLLER
ENCODER
PATTERN
GENERATOR
WRITING
MEANS
320
BUFFER
DEVICE DRIVER
312
FILE SYSTEM
311
310
270
APPLICATION
SOFTWARE
OPERATING SYSTEM
(OS)
INPUT SIGNAL
260
INPUT MEANS
280

FIG. 4

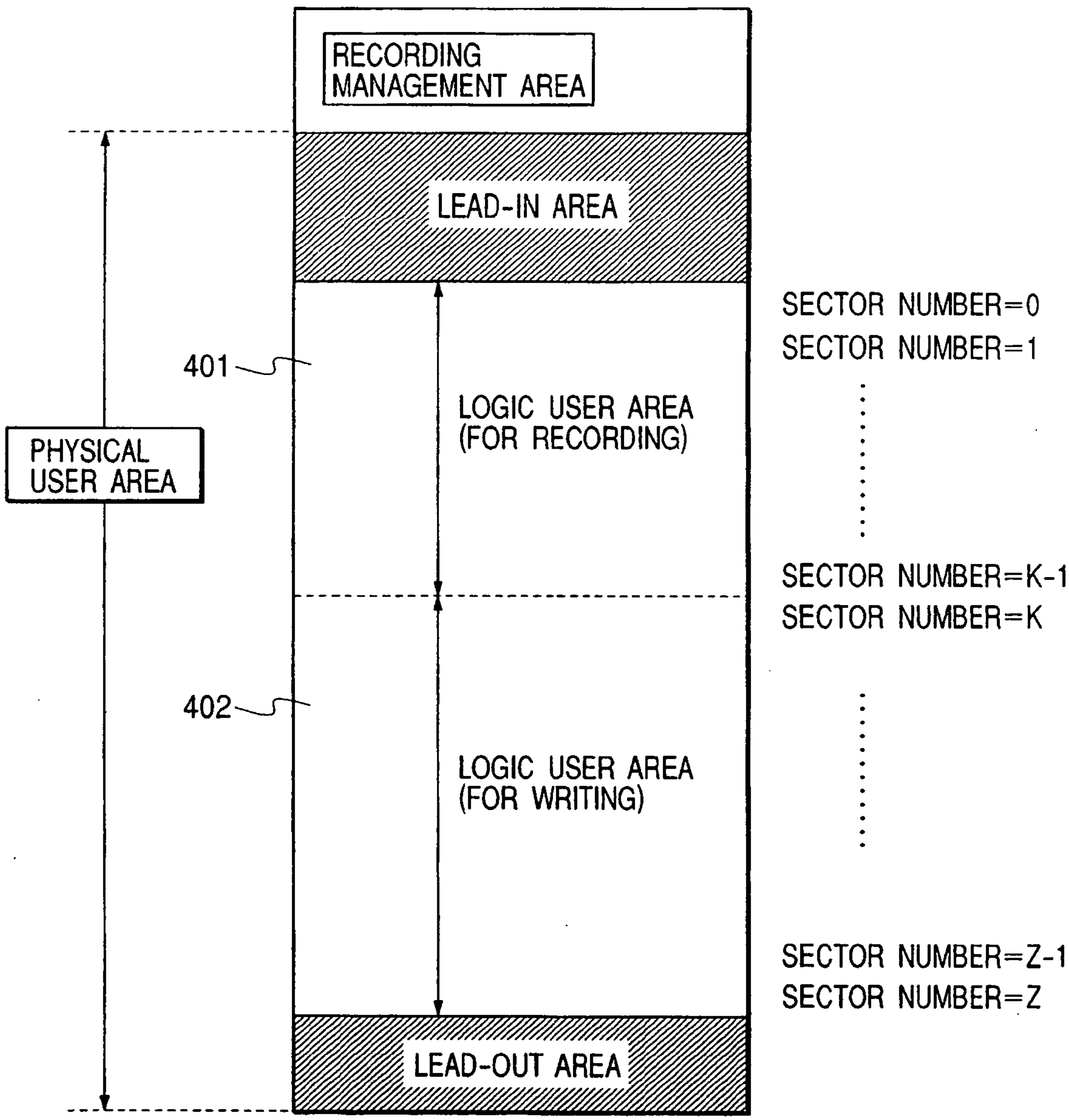

RECORDING MANAGEMENT AREA
LEAD-IN AREA
PHYSICAL USER AREA
401
LOGIC USER AREA (FOR RECORDING)
402
LOGIC USER AREA (FOR WRITING)
LEAD-OUT AREA
SECTOR NUMBER=0
SECTOR NUMBER=1
SECTOR NUMBER=K-1
SECTOR NUMBER=K
SECTOR NUMBER=Z-1
SECTOR NUMBER=Z

FIG. 5

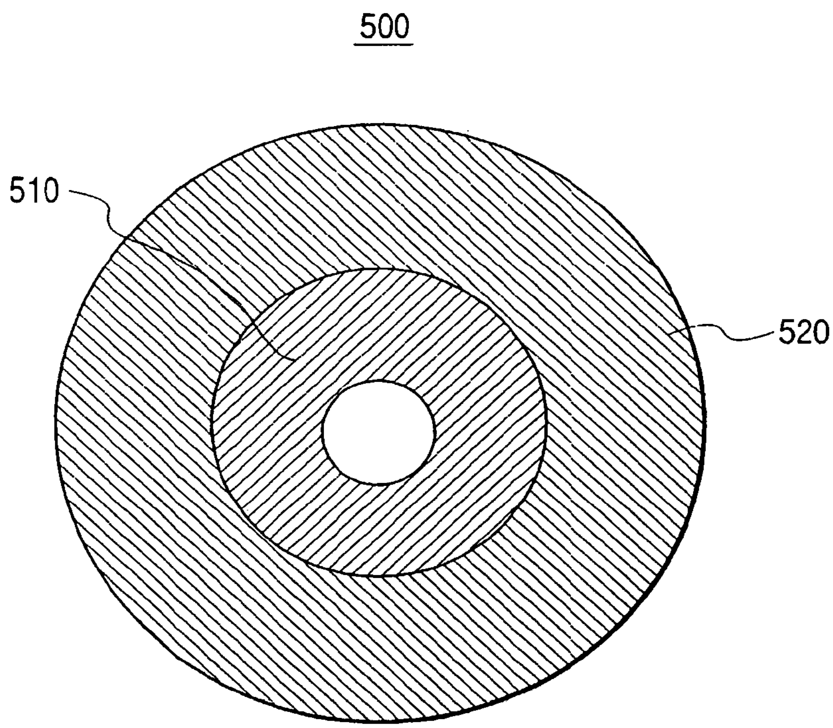


FIG. 6

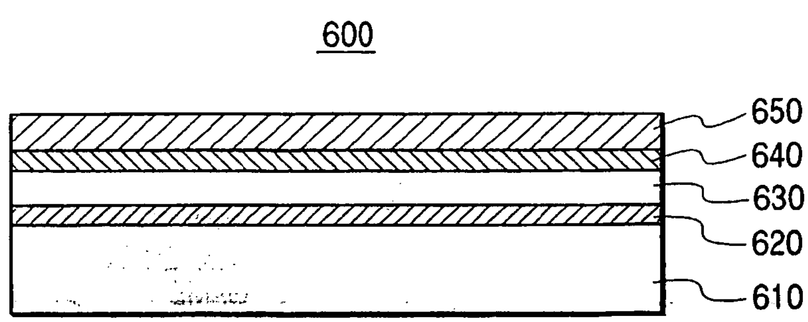


FIG. 7(a)

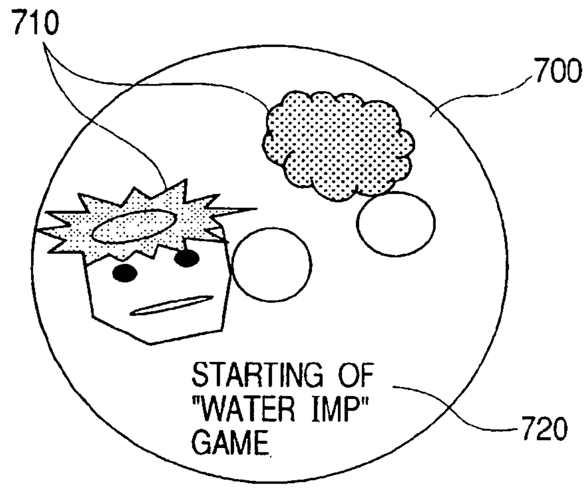


FIG. 7(b)

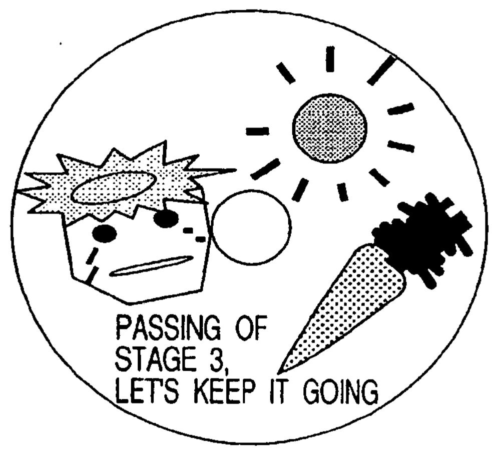


FIG. 7(c)

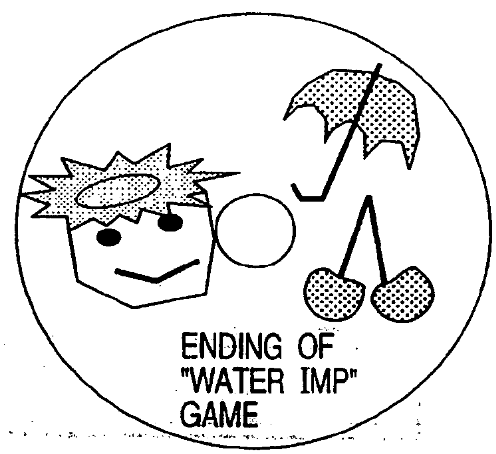


FIG. 8(a)

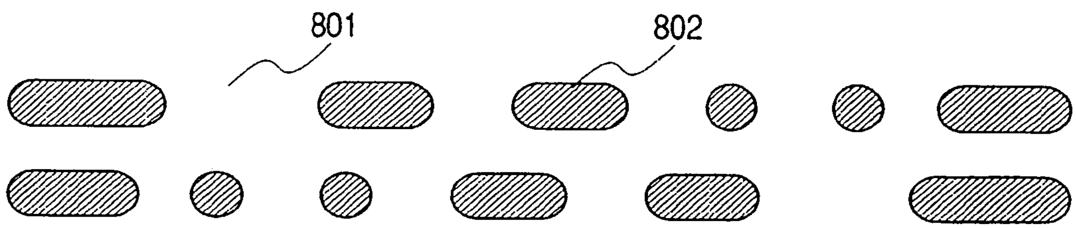


FIG. 8(b)

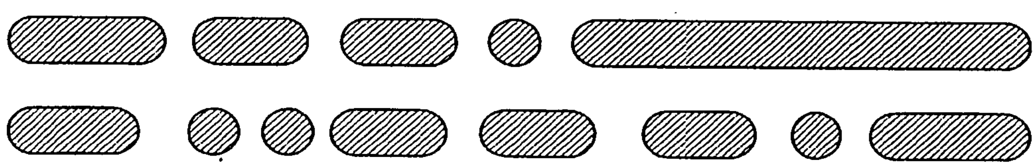


FIG. 9(a)

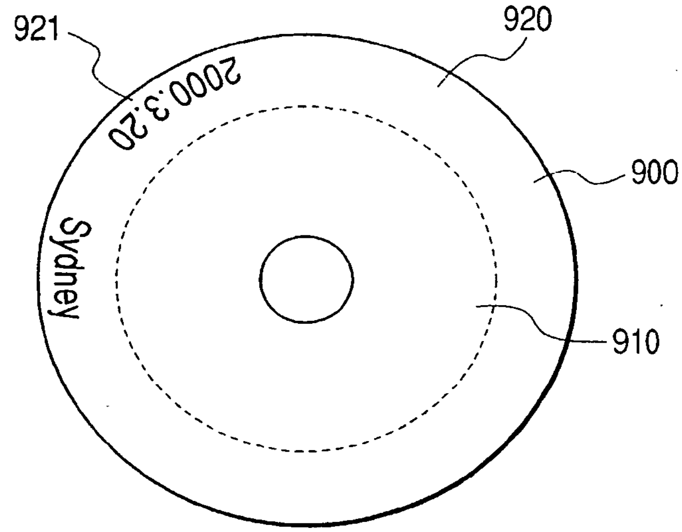

921
920
2000.3.20
900
Sydney
910

FIG. 9(b)

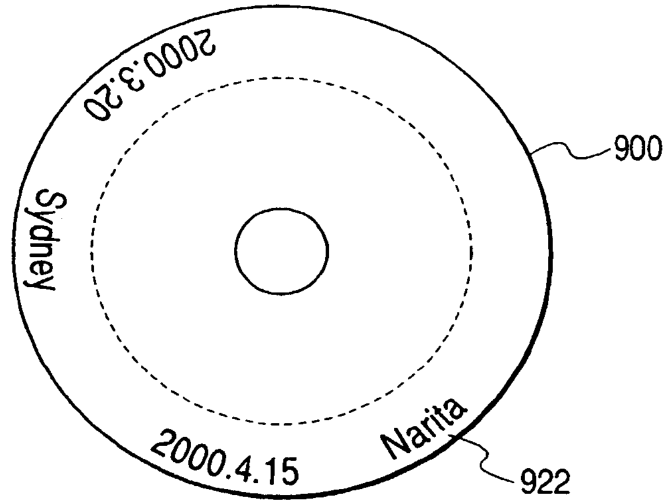

2000.3.20
900
Sydney
2000.4.15
Narita
922

FIG. 10

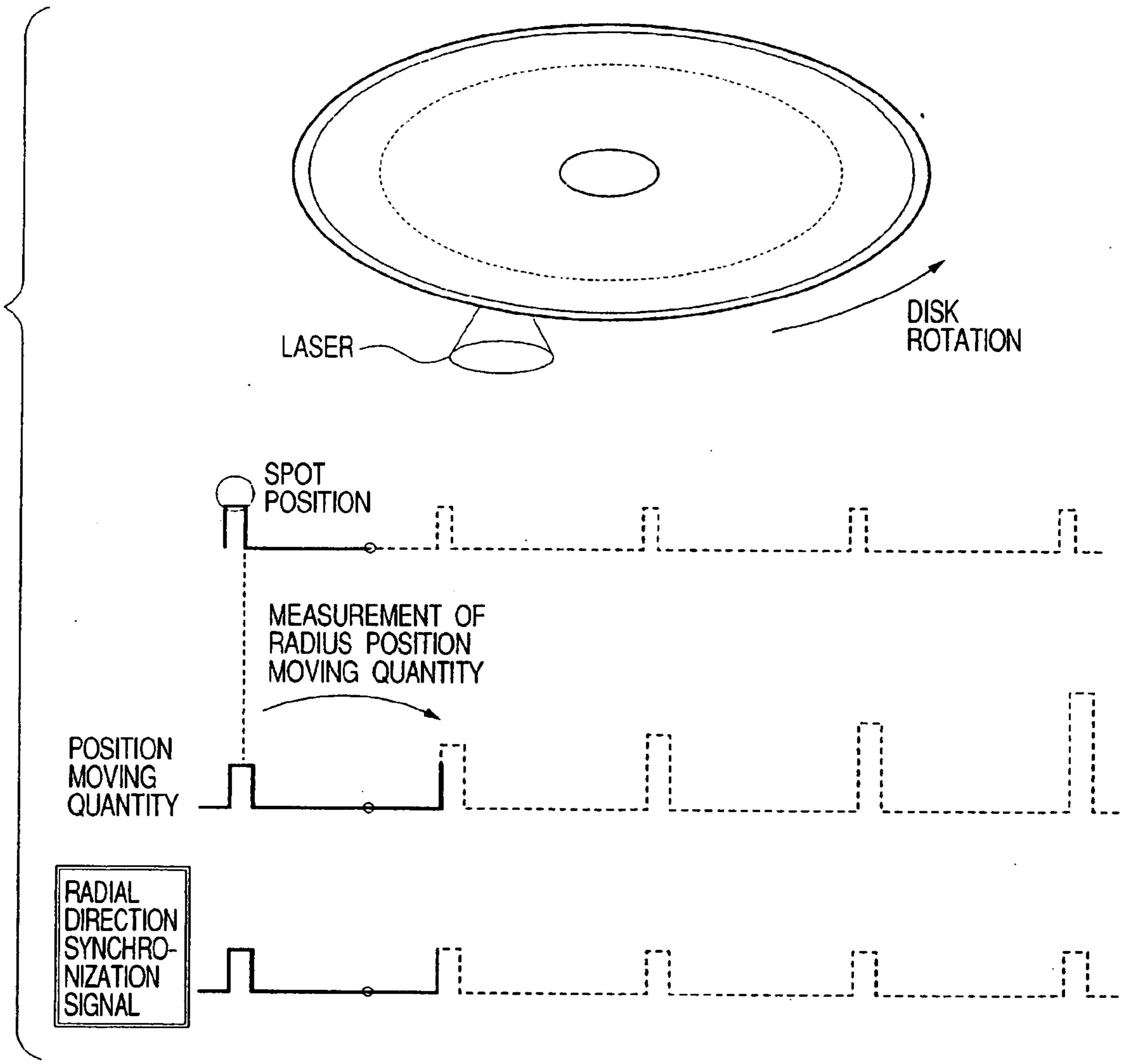

LASER
DISK ROTATION
SPOT POSITION
MEASUREMENT OF RADIUS POSITION MOVING QUANTITY
POSITION MOVING QUANTITY
RADIAL DIRECTION SYNCHRO- NIZATION SIGNAL

FIG. 11

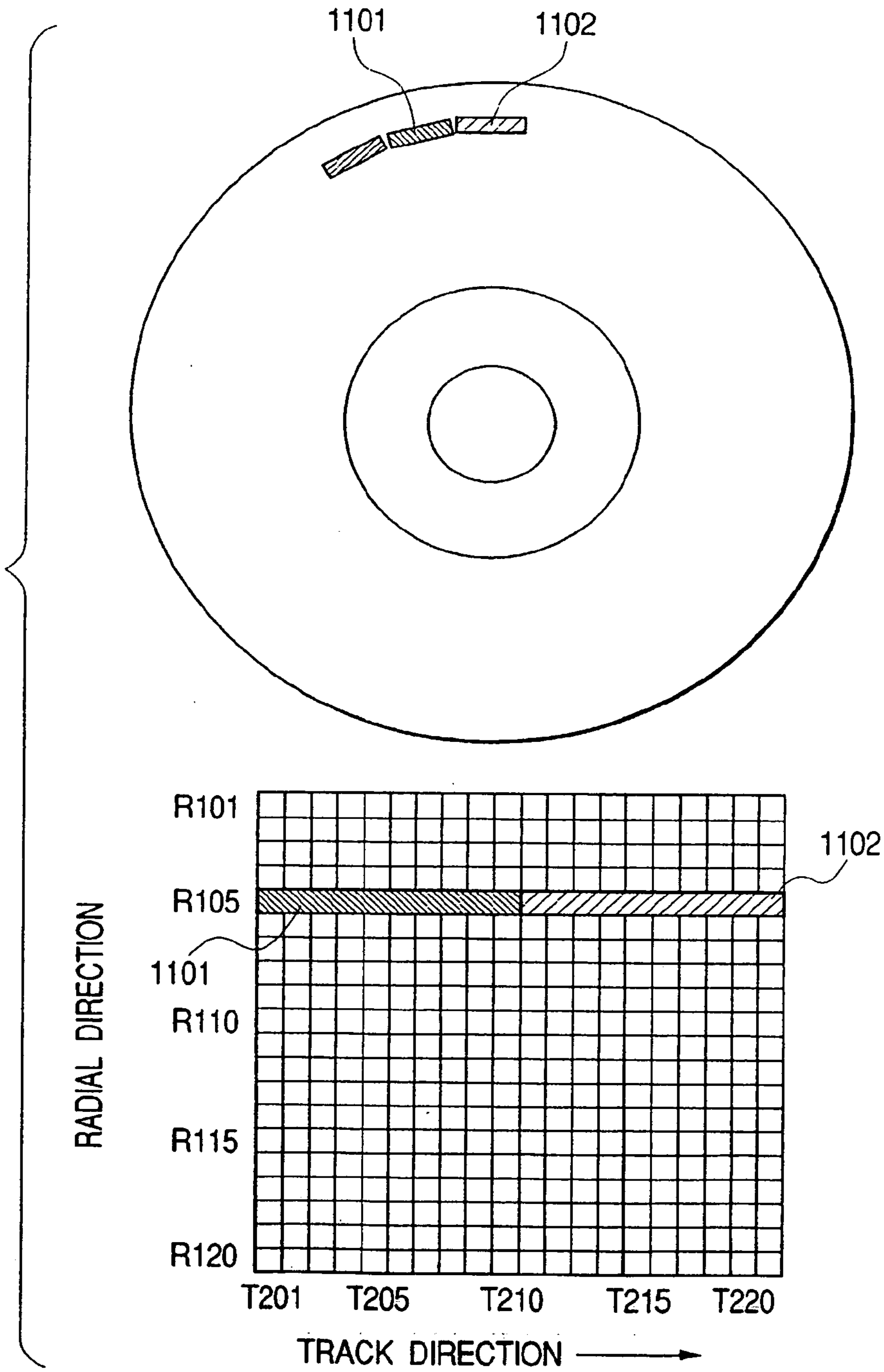

1101
1102
R101
R105
R110
R115
R120
1102
1101
RADIAL DIRECTION
T201
T205
T210
T215
T220
TRACK DIRECTION

FIG. 12

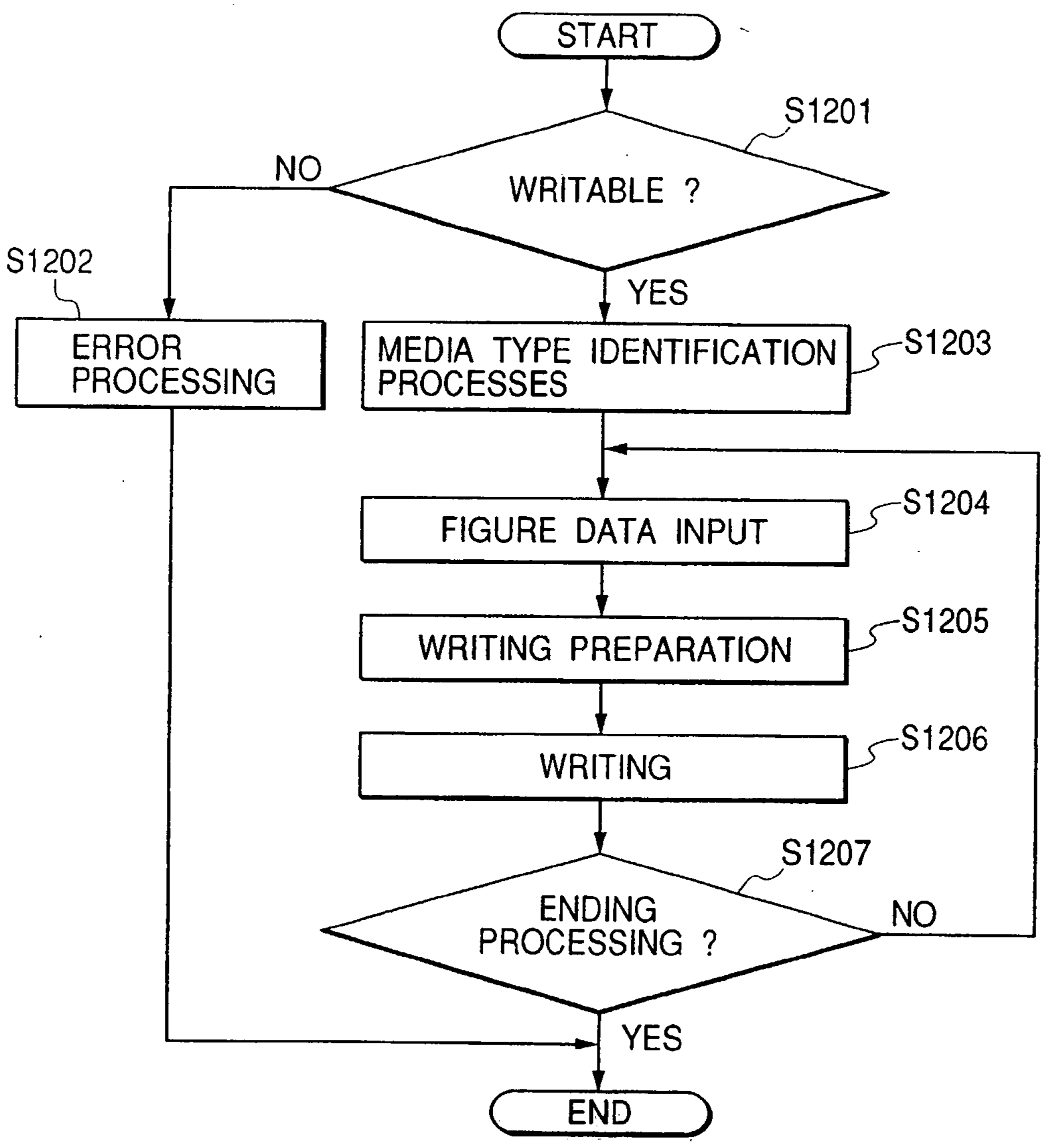

START
S1201
WRITABLE ?
NO
S1202
ERROR PROCESSING
YES
MEDIA TYPE IDENTIFICATION PROCESSES
S1203
FIGURE DATA INPUT
S1204
WRITING PREPARATION
S1205
WRITING
S1206
S1207
ENDING PROCESSING ?
NO
YES
END

FIG. 13

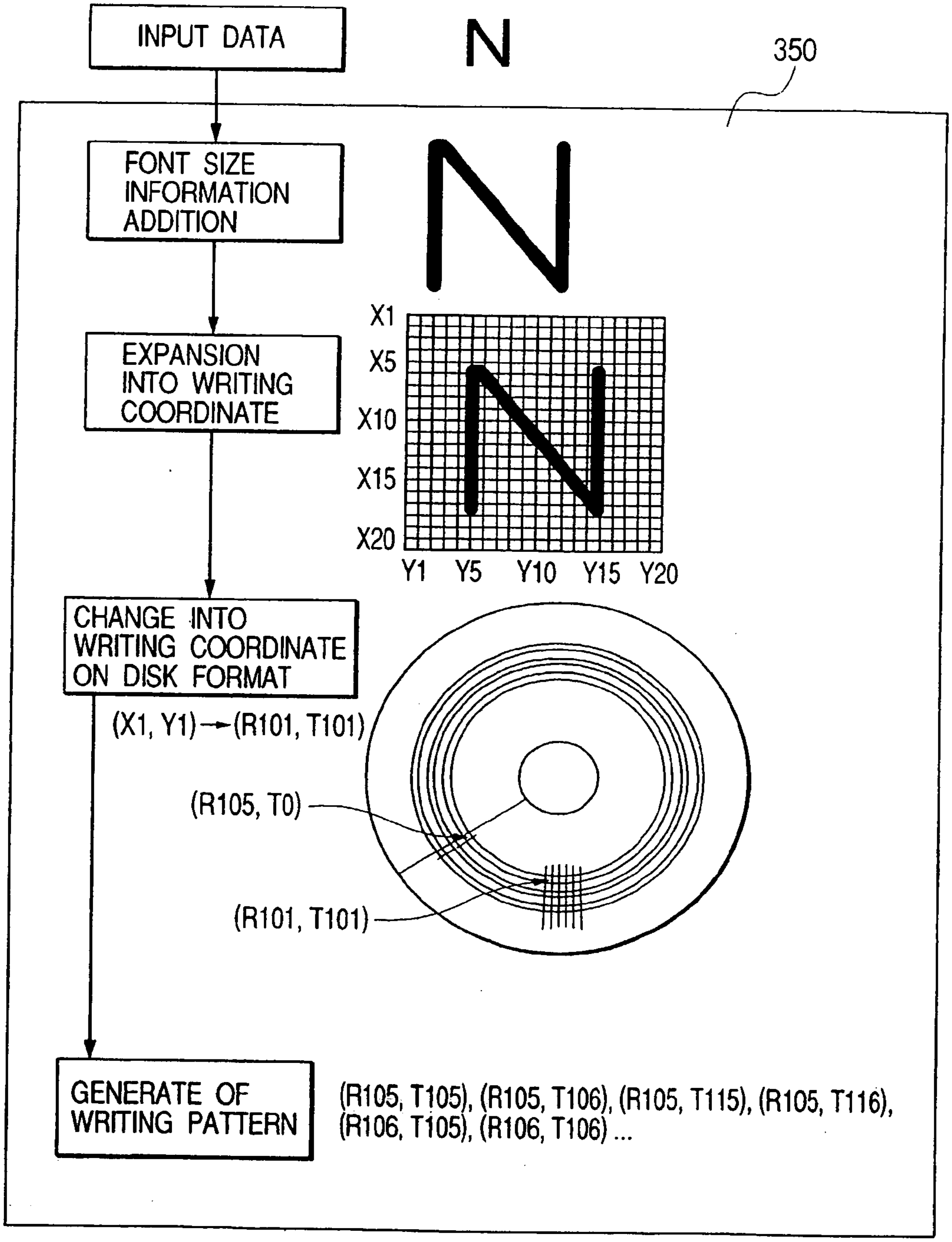

INPUT DATA
N
350
FONT SIZE INFORMATION ADDITION
N
EXPANSION INTO WRITING COORDINATE
X1
X5
X10
X15
X20
Y1 Y5 Y10 Y15 Y20
N
CHANGE INTO WRITING COORDINATE ON DISK FORMAT
(X1, Y1)→(R101, T101)
(R105, T0)
(R101, T101)
GENERATE OF WRITING PATTERN
(R105, T105), (R105, T106), (R105, T115), (R105, T116), (R106, T105), (R106, T106) ...

FIG. 14

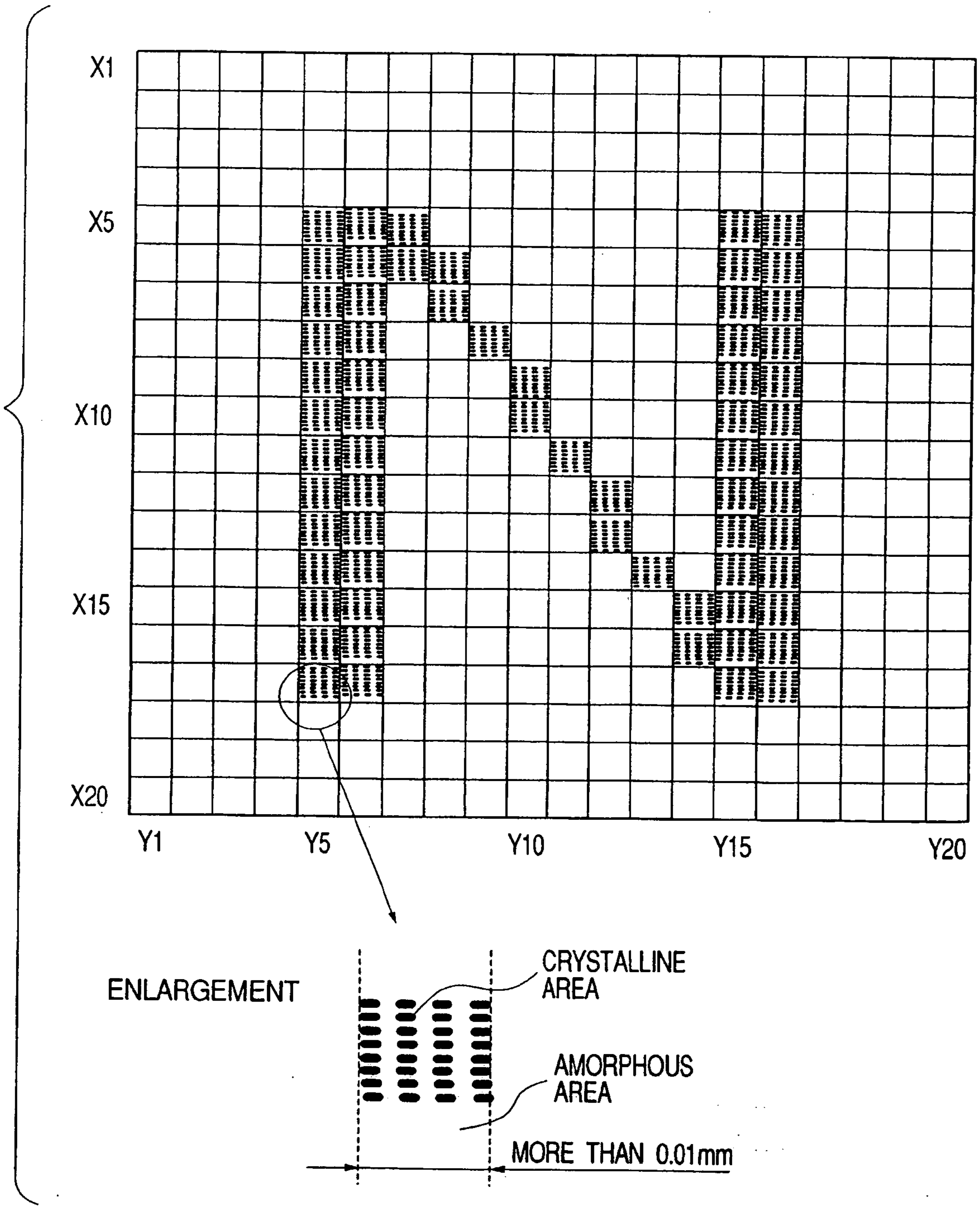

X1
X5
X10
X15
X20
Y1
Y5
Y10
Y15
Y20
ENLARGEMENT
CRYSTALLINE AREA
AMORPHOUS AREA
MORE THAN 0.01mm

FIG. 15

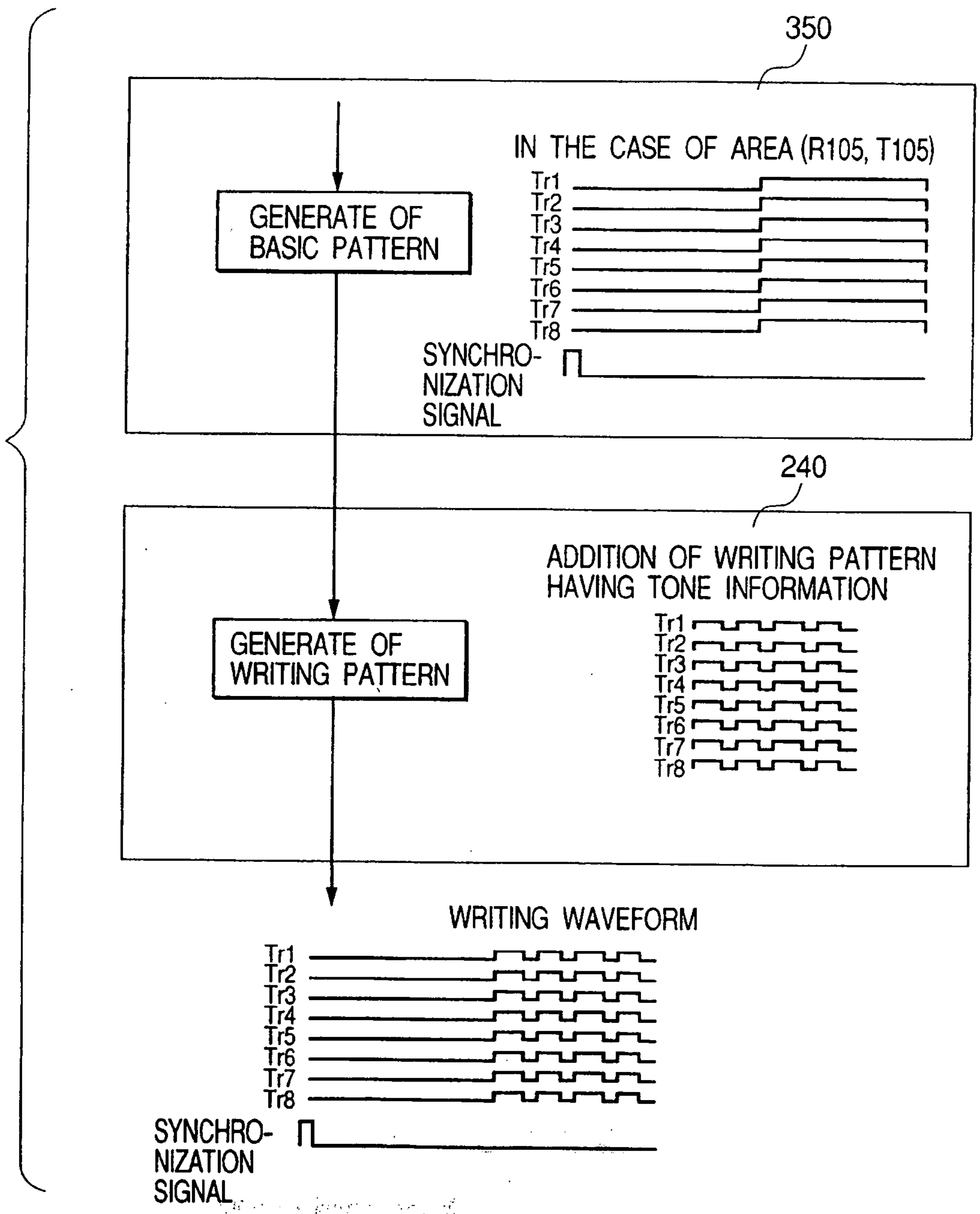

350
IN THE CASE OF AREA (R105, T105)
GENERATE OF BASIC PATTERN
Tr1
Tr2
Tr3
Tr4
Tr5
Tr6
Tr7
Tr8
SYNCHRO-NIZATION SIGNAL
240
ADDITION OF WRITING PATTERN HAVING TONE INFORMATION
GENERATE OF WRITING PATTERN
Tr1
Tr2
Tr3
Tr4
Tr5
Tr6
Tr7
Tr8
WRITING WAVEFORM
Tr1
Tr2
Tr3
Tr4
Tr5
Tr6
Tr7
Tr8
SYNCHRO-NIZATION SIGNAL

FIG. 16(a)

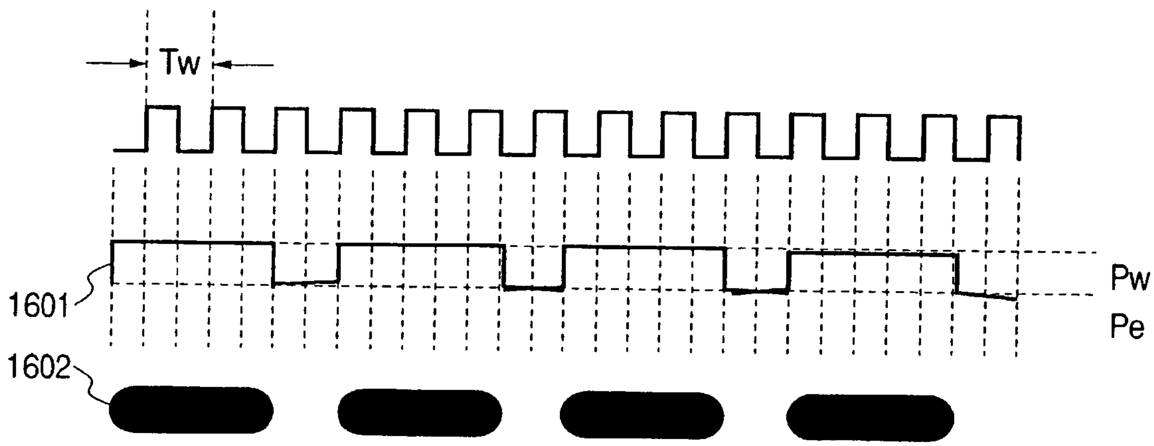


FIG. 16(b)

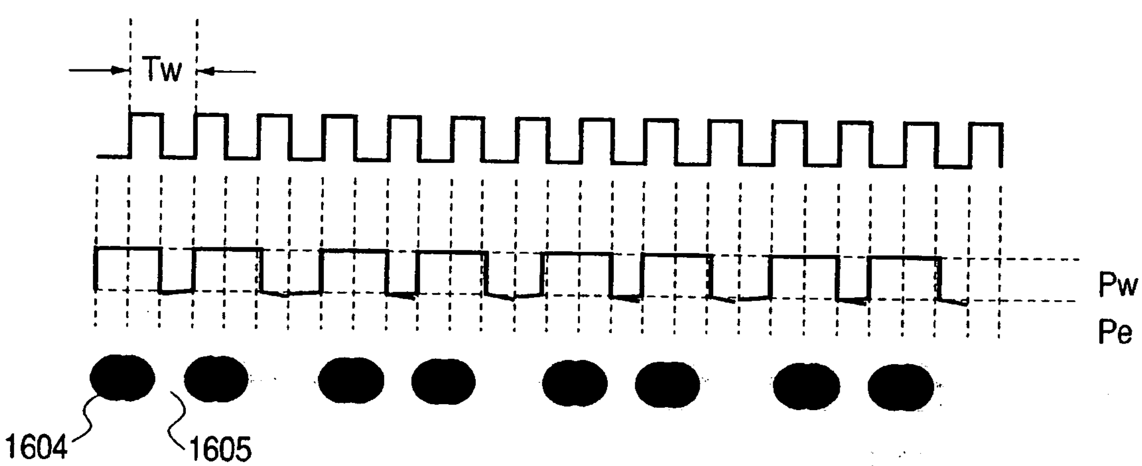


FIG. 17(a)

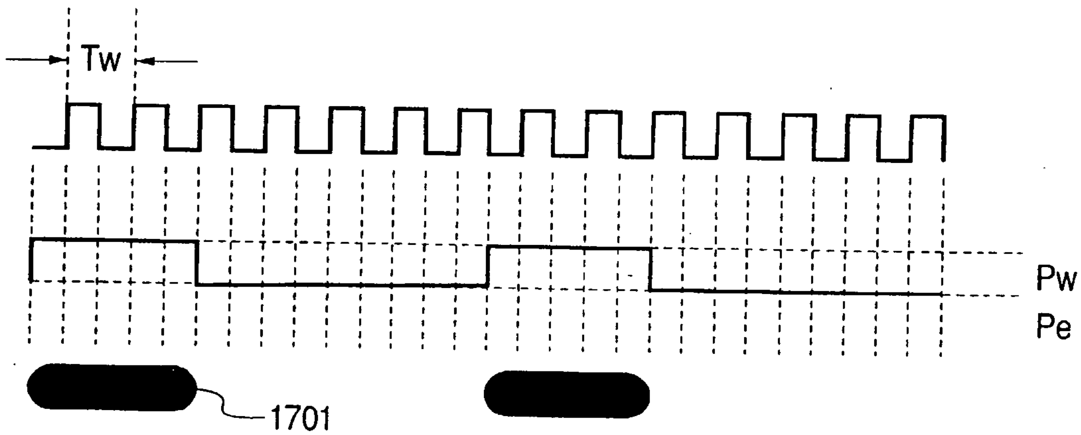


FIG. 17(b)

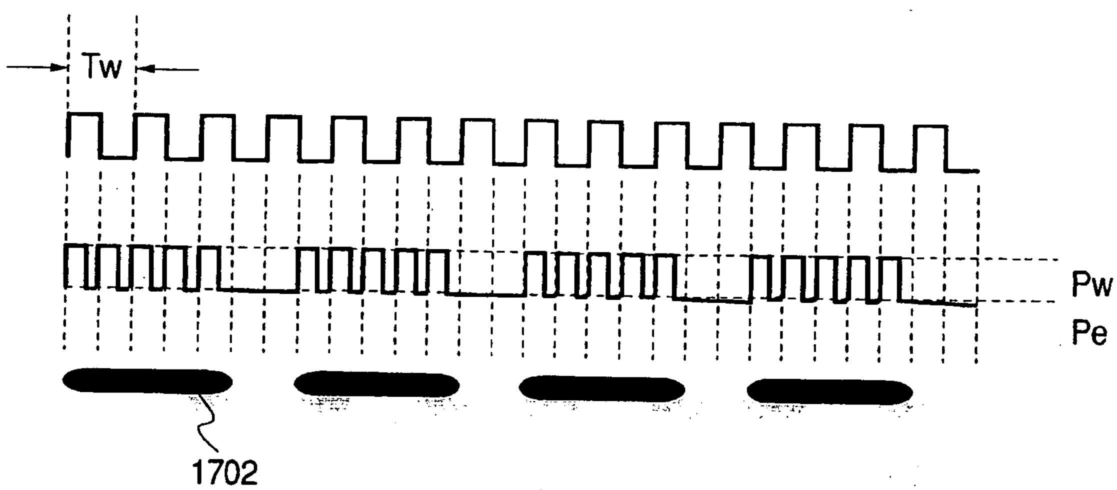


FIG. 18

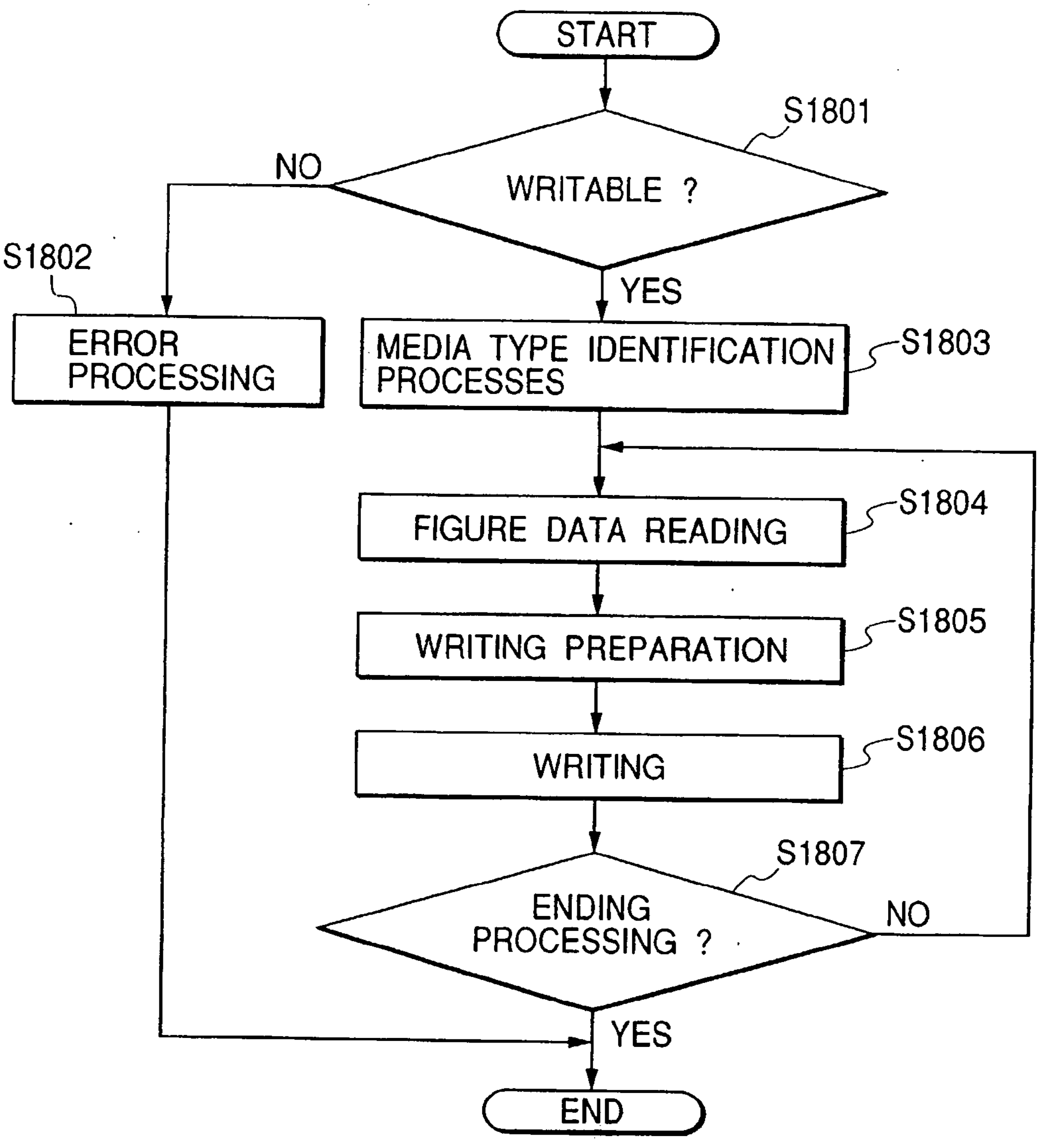

START
S1801
WRITABLE ?
NO
YES
S1802
ERROR PROCESSING
MEDIA TYPE IDENTIFICATION PROCESSES
S1803
FIGURE DATA READING
S1804
WRITING PREPARATION
S1805
WRITING
S1806
S1807
ENDING PROCESSING ?
NO
YES
END

FIG. 19(a)

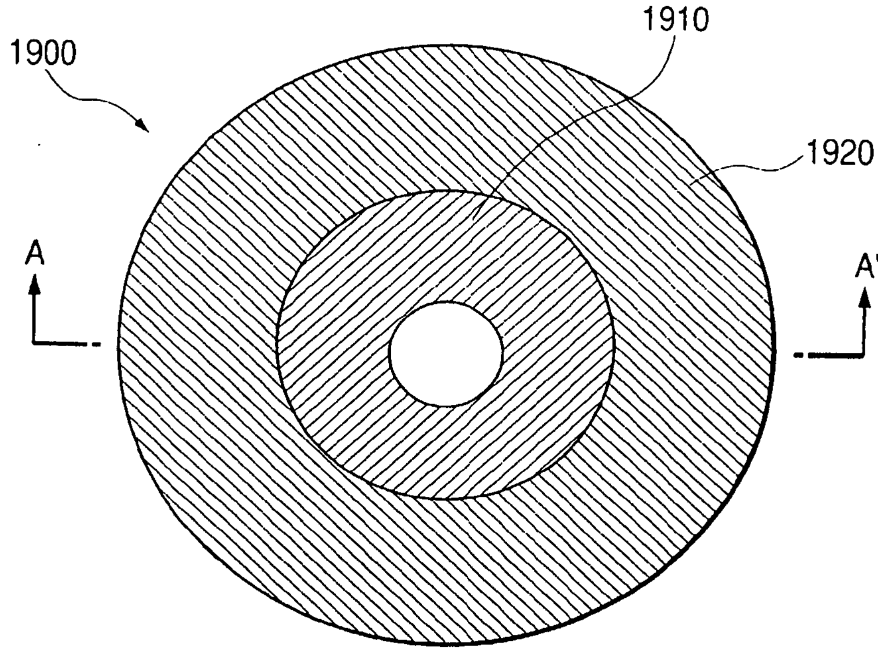


FIG. 19(b)

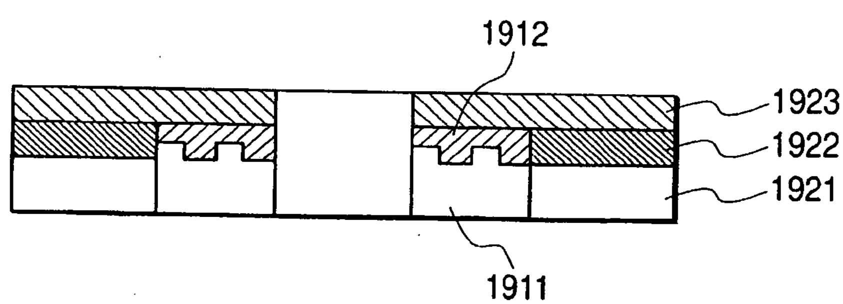


FIG. 20(a)

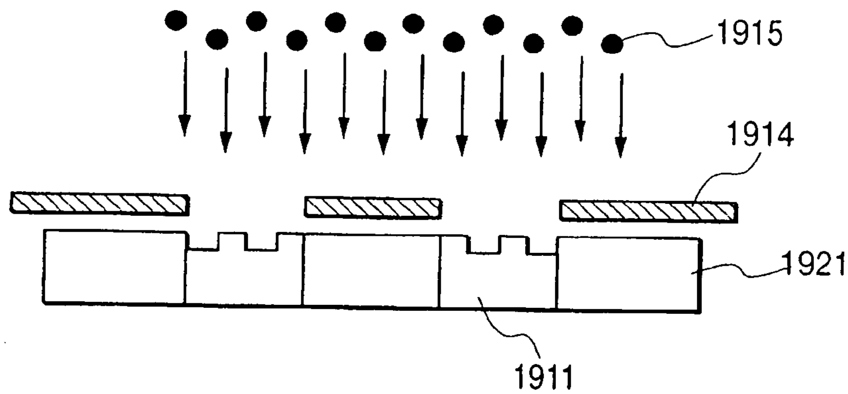


FIG. 20(b)

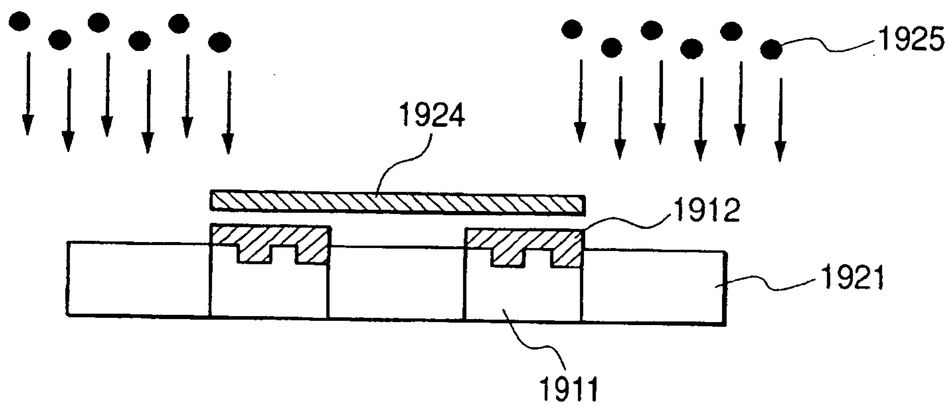


FIG. 20(c)

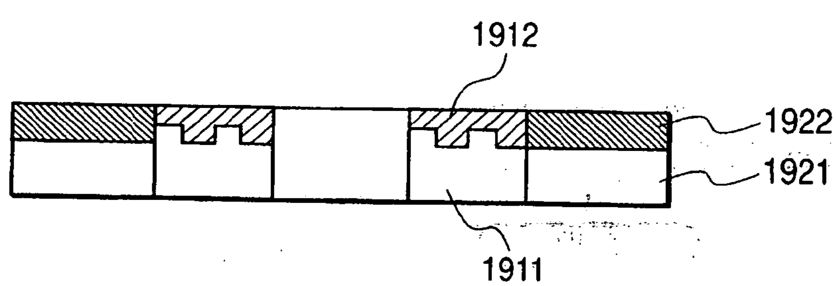
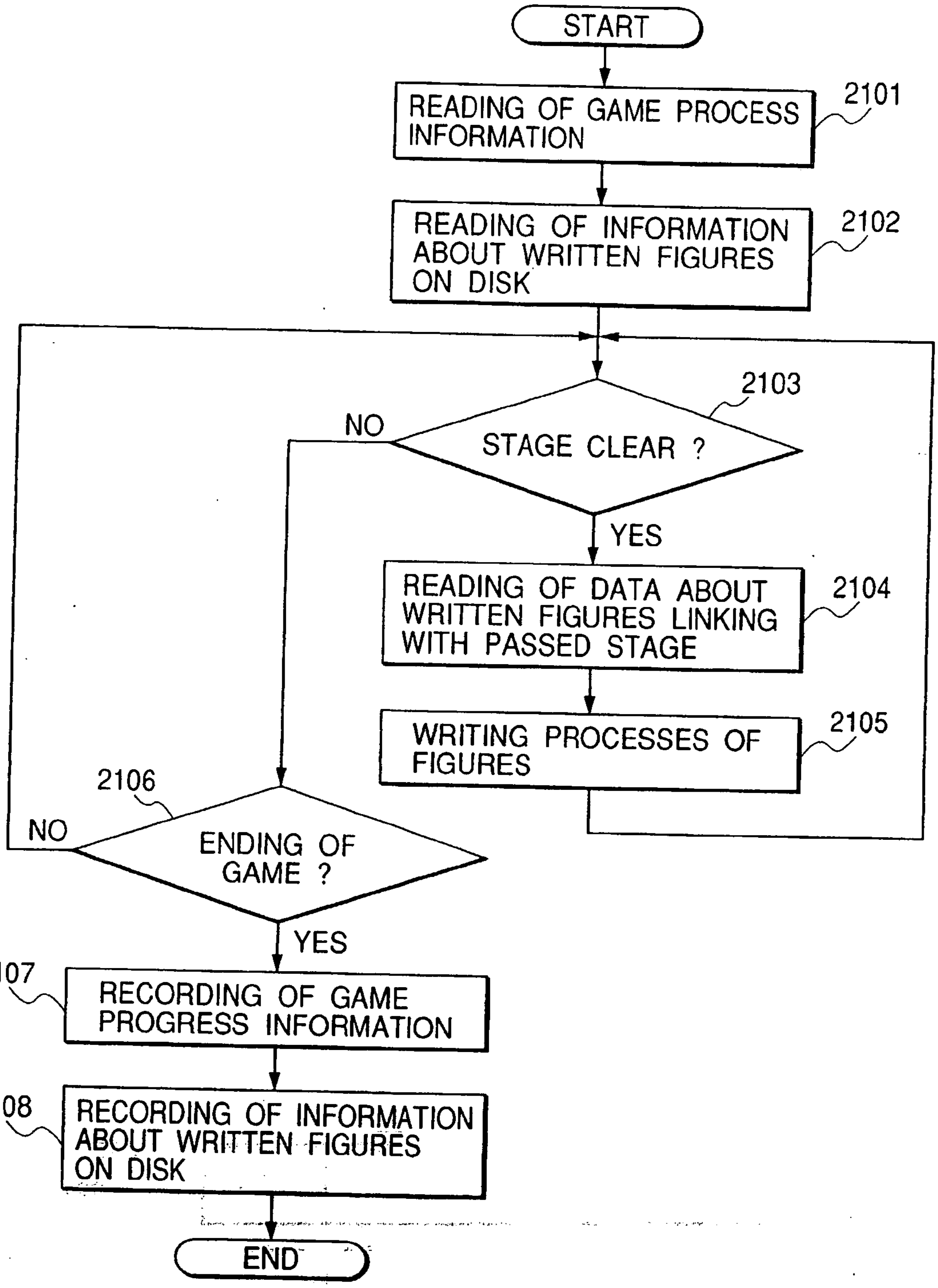


FIG. 21


START
READING OF GAME PROCESS INFORMATION
2101
READING OF INFORMATION ABOUT WRITTEN FIGURES ON DISK
2102
STAGE CLEAR ?
2103
NO
YES
READING OF DATA ABOUT WRITTEN FIGURES LINKING WITH PASSED STAGE
2104
WRITING PROCESSES OF FIGURES
2105
ENDING OF GAME ?
2106
NO
YES
RECORDING OF GAME PROGRESS INFORMATION
2107
RECORDING OF INFORMATION ABOUT WRITTEN FIGURES ON DISK
2108
END